ITEA 2
INFORMATION TECHNOLOGY FOR EUROPEAN ADVANCEMENT

- TWIRL -

Twinning virtual **W**orld (on-line) **I**nformation with
Real world (off-**L**ine) data sources

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1 INTRODUCTION

TWIRL (Twinning virtual World (on-line) Information with Real world (off-Line) data sources) project will going to augment real-world applications with knowledge and information that has been extracted from virtual data sources like social networks (OSN) by creating an open platform able to acquire, intelligently process and enrich large volumes of heterogeneous data.

This report is the state of the art of the TWIRL project, and will introduce the available resources of information for travelling and tourism aspects. Also here the methodologies that is going to be used for crawling the information from available resources is discussed. As one of the main available information that can be used here is images, the techniques for recognizing the images and processing the information behind them has been discussed in this report. This report will give us the required basement for other tasks and deliverable specially for proposing the usecases scenarios of the project.

2 SOCIAL MEDIA IN TWIRL CONTEXT

2.1 Introduction

As Social media is playing an increasingly important role as information sources for travellers here In this section mainly we introduce the available social media for tourism industry as well as we describe the possibility of using social TV in the project.

2.2 Social Media for Travelling

2.2.1. Impact of Social media during the travel planning process

Nowadays social media constitute significant networks of user knowledge that influence user behaviour [28]. As it is the case with many other economic sectors and industries, tourism is affected by the existence and increasing use of social media as they "are taking an important role in travellers' information search and decision-making behaviours" [92]. The content of such social media is perceived as similar to recommendations provided by friends or family members[33][87], thus becoming a vital information source to potential tourists [22]. Gretzel, Yoo, & Purifoy [39] studied reviews in TripAdvisor[1] and found that online reviews increase potential travellers' confidence about decisions making, reduces risk, facilitates them to reach a decision and assists them in planning their trip, especially in selecting accommodation.

Researches on travel and tourism-related blogs underscore the interest in understanding the functions of blogs in creating and sharing new experiences [71], as well as its trustworthiness to online travellers [57]. As evidenced by the success of Websites like TripAdvisor, online travel-related users' reviews also represent a significant amount of social media for travel purposes [38]. The studies on this type of social media focus on its use as well as its impact on travel decision making. Multimedia sharing (i.e., video, photos, podcasting, etc), represented by Websites such as YouTube and Flickr, has attracted tourism researchers by generating interests in understanding the role of this type of social media content in transforming travel experiences [85].

A study [35] attempts to describe the role and impact of social media on how holiday makers plan and consume holidays. This study pursues among other, the following objectives: (1) To measure the exposure and role of social media before, during and after the holiday trip, (2) To measure the social media level of influence on holiday plans and (3) To measure the level of trust towards social media in relation to traditional sources of holiday related information.

To describe exposure to and role of social media during the holiday planning process, respondents (Russians and residents of the other FSU Republics) were requested to think back (a) before their departure to their last holiday, (b) during their last holiday, and (c) after their last holiday. The study reveals that social media are used during all stages of the holiday planning process (before, during and after holidays), however, to a different extent and for a different purpose (see Figure 1): The study evidences that travellers use social media predominantly during the post-trip stage for sharing experiences and photos with friends and / or other travellers. The second most popular use of social media was observed during holidays, as means that enable travellers to stay connected with friends.

[1] http://www.tripadvisor.fr/ : a travel website that assists customers in gathering travel information, posting reviews and opinions of travel-related content and engaging in interactive travel forums. (source Wikipedia)

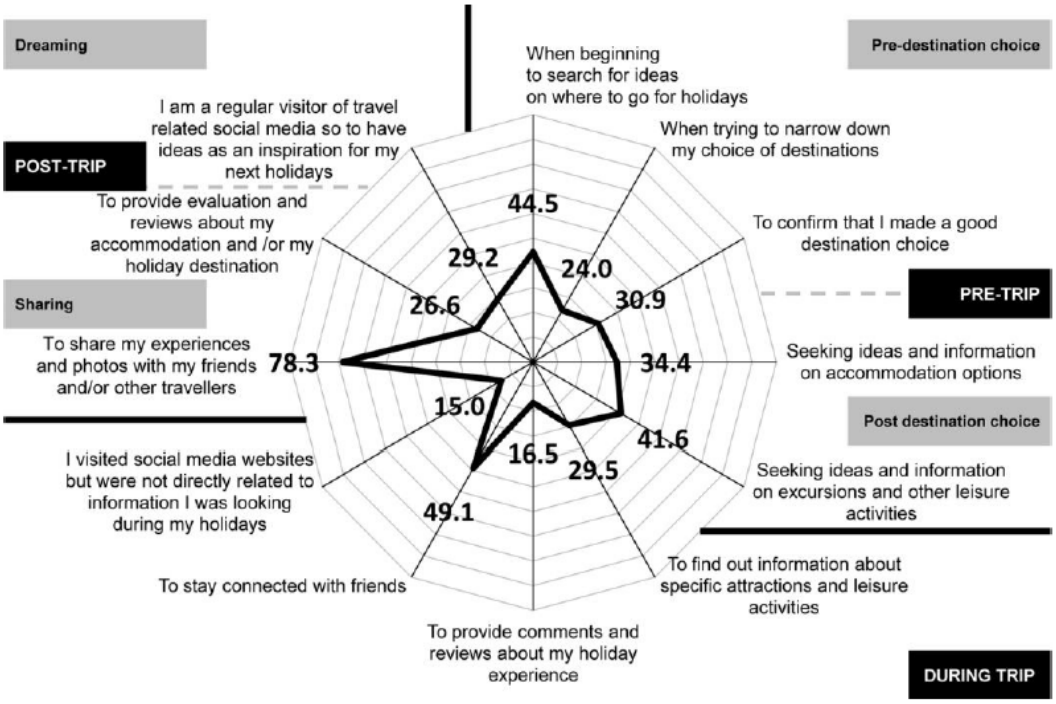

Figure 1: Percentage of respondents that used social media during their travel planning process and reason of use [35]

In terms of influence, social media were rated as "somehow influential" on both destination and accommodation choice. However, 65% respondents stated that they indeed made some sort of changes to their original plans because of exposure to user-generated content in social media websites, with 50% describing them as "few changes" and 15% as "significant changes". Moreover, it was revealed that as the perceived level of influence from social media on destination or accommodation choice increases, the more likely is that there were changes in the holiday plans.

This study also examined the perceived level of trust of seven holiday related information sources: Official tourism websites, publicity and advertorials in mass media (i.e., TV or radio shows and documentaries, newspapers and magazines' articles), advertisements in mass media, travel agents, social media, friends and relatives, and information from other travellers in various websites. Among those, friends and relatives were rated as the most trusted source, followed by information from other travellers in various websites. In contrast to the findings of [23] who found that state tourism websites and travel agents outscored, in terms of trust, comments by other travellers found in third party sites (i.e. TripAdvisor), blogs and social network sites, this study found that information from other travellers in various websites is trusted more than official tourism websites, and travel agents.

To conclude, more and more travellers seem to tap into the ''collective intelligence'' available on the Web [54], to plan and consume holidays, making thereby social media a major actor in the travel experience.

We present in section 2.2.2 some existing research and initiatives related to the use of social media in travelling, and we list in section 2.2.3 some location-based social networking applications.

2.2.2. Existing research projects and initiatives

There is several related research work regarding to possibility of using social media information for travelling. Authors in [130] tried to better understand the role of social media in travel information search by examining popular travel-related keywords in Google. These words were combined with 9 U.S. cities, in order to narrow down the research results. The bottom line: among almost 11,000 search results, 11% were identified as results representing social media sites. In other words, the research indicates that search engines tend to direct travelers to Facebook, Twitter, TripAdvisor and other social media sites very often. This is why you should be there too with a powerful, professional page or account that has to be updated regularly. This is why you have to talk with your customers, reply, retweet, share and listen.

In other similar work [226] authors argue that social network services play a pivotal role in a college students' trip information search behavior. They analyze this by providing an online survey to college students in the Midwest United States. The total valid sample size was 156 individuals. 58.4% (n = 87) of the respondents were male and 41.6% (n = 62) were female. Hierarchical regression analysis was employed to test the hypotheses. The results indicate that social life documenting and community forum participation are the key factors affecting behaviors to use SNSs for travel-related information seeking. It is also observed that interaction to others on the systems significantly increase the use of SNS. Implications and suggestions for future research were discussed.

Ref. [227] evaluates users social interaction with online social networks (OSNs) by testing a theoretical model, which consists of consequences of social interactions in an OSN travel context. An online self-administered questionnaire was sent to a systematic random sample of 12000 college students at six US universities, and 513 respondents in total participated in the study. Study results suggest that innovativeness, perceived utility, and information sharing are effective for developing online social interaction.

In [228] author selects nine Chinese tourism cities as sample with different city level, population size and geographic location, uses six main travel-related keywords to study empirically social media impact on online travel information search by Baidu search engine. The results show that social media websites constitute approximately 50% search results, indicating search engine may directly guide travelers to social media websites. The study emphasizes the growing important of social media in travelers' online trip planning and provides marketing suggests.

Also as we are going to use images as a source of media information in this project, in one study in this area authors in [229] explores whether travelers who post pictures on a social media site(s) of their trip have different souvenir purchasing behaviors than those who do not engage in trip picture posting.

Apart from all the mentioned research, there are plenty of applications available on the internet that are developed the platform of social media for tourism industry as you can find many of them in different categories in a post namely Travel Smarter [230].

2.2.3. Existing Platforms and tools

Many Web and mobile applications are plugging into social networks, GPS functions and/or other tools to provide inspiration, real-time information and recommendations on where to go, what to see and even who to hang out while travelling.
A set of such applications is briefly detailed below. The first paragraph (2.2.3.1) brings together applications that are likely used before and after the trip (get social recommendations, ask for information, share photos, rates…), while the second paragraph (2.2.3.2) presents applications that are used rather during the trip (use user's GPS localization to propose social recommendations)

2.2.3.1. Destination-based social networking applications

2.2.3.1.1 MyTravelCompanions[2]

MyTravelCompanion is a travel-based Website that helps its members to find like-minded travelling companions, fulfill all their travelling needs, and share travel tips: Members log on to find potential companions from their peer group and share experiences and advice through travel diaries, forums and photo albums. MyTravelCompanions also serves as a travel info aggregator, trip planner and booking portal. Taking the community offline, local networking events are already being hosted in towns and cities across the world, allowing members to meet face-to-face to talk about their trips and find local travel companions.

2.2.3.1.2 Gogobot

Gogobot is a social travel recommendation application that helps users to plan their trip quickly and efficiently by using the expertise of their Facebook and Twitter networks.
Gogobot encourages users to capture and share adventures with personalized "postcards." User can see where friends have travelled, get tips from other travellers and show off all of the places he's been.
Gogobot provides advice from people who live or have experience in user's desired destination. User can "follow" members who have similar interests, post questions, write reviews or browse photos. Gogobot also lists hotels, vacation rentals and restaurants.

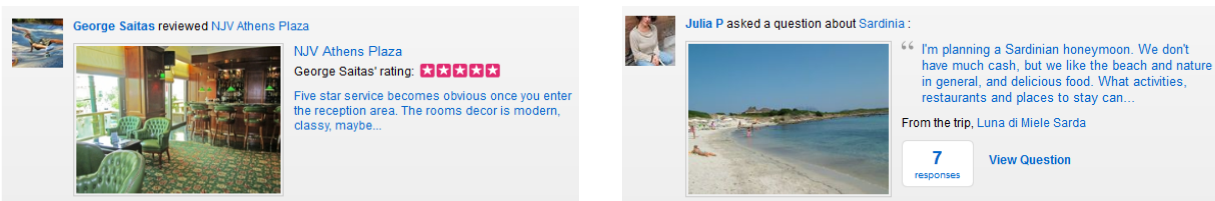

Figure 2: Examples of Gogobot Screenshots

2.2.3.1.3 JetPac

JetPac is a travel Guide from friend's photos. It mines user's personal networks to generate galleries of travel pictures and recommendations user can use for travel inspiration.

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[2] http://www.mytravelcompanions.com

JetPac is making useful the hundreds of millions photos uploaded to Facebook each day, by figuring out where they're from, even when they're not explicitly geo-tagged, prioritizes the best to use in the application and to propose to users.

Figure 3: An example of JetPac Screenshot

2.2.3.1.4 Trippy

Trippy is a social travel application that aims to simplify and improve travel planning through what they call "friend-sourcing." The app ties into users' social networks, such as Facebook, to discover which friends, family and contacts have visited the considered destination, whether they have checked-in, lived, worked, or studied there.
Through one-click recommendations and Facebook-style commenting, Trippy lets friends suggest what hotels, restaurants, and destinations would be a good fit. Users can add places they're considering so that friends can comment on the itinerary, offering feedback in Facebook-style comment feeds.

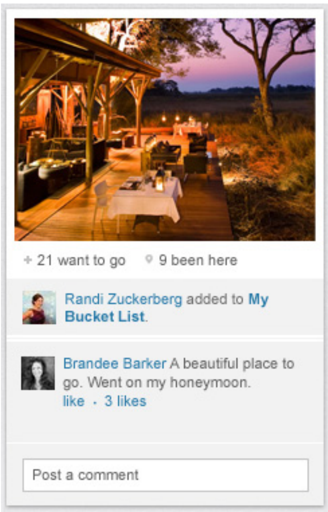

Figure 4: An example of Trippy Screenshot

2.2.3.1.5 Tripl

Tripl is a travel recommendation network that focuses more on people than on places, integrating information from Facebook and LinkedIn to show the user's personal connections around the world and help him meet locals when he is travelling. Back at home, the user can share photos, give advice or serve as a guide to other travellers.

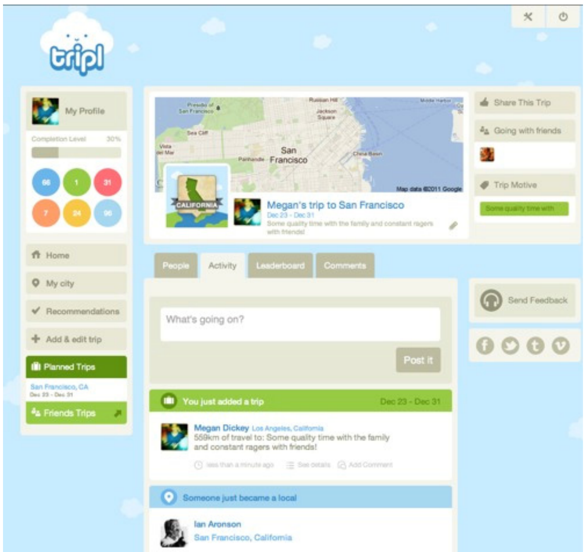

Figure 5: An example of Tripl Screenshot

2.2.3.2. Location-based social networking applications

2.2.3.2.1 Foursquare

Foursquare is a location-based social networking website for mobile devices. Users "check in" at venues using a mobile website, text messaging or a device-specific application by selecting from a list of venues the application locates nearby. Location is based on GPS hardware in the mobile device or network location provided by the application. Each check-in awards the user points and sometimes "badges".

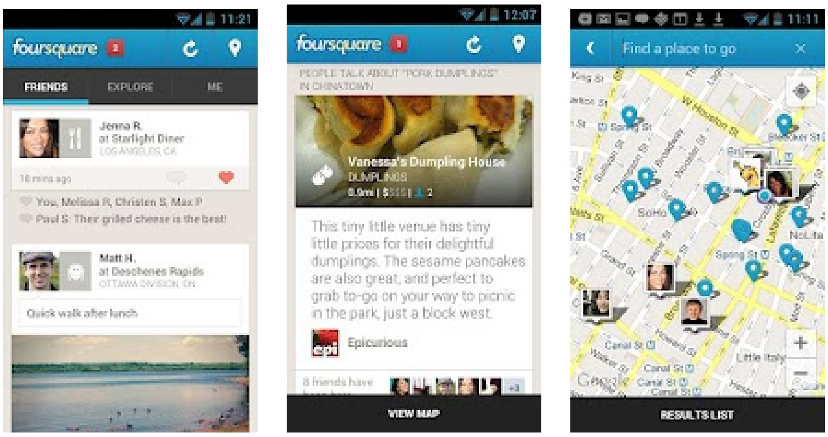

Figure 6: Examples of Foursquare Screenshots

Foursquare has also a developer API that allows users to plug foursquare data into other applications.

2.2.3.2.2 Yelp

Yelp is a social networking, user review, and local search web site. It allows users to find and talk about local businesses. Yelp provides users with online local search capabilities: A typical search includes what the user is seeking and the location from which the search is to be performed.
Yelp combines local reviews and social networking functionality to create a local online community. Adding social web functionality to user reviews creates a reputation system.
Yelp uses also Yelp TALK and Yelp MESSAGING to offer yelpers' the ability to connect on a more personal level within the virtual review community.

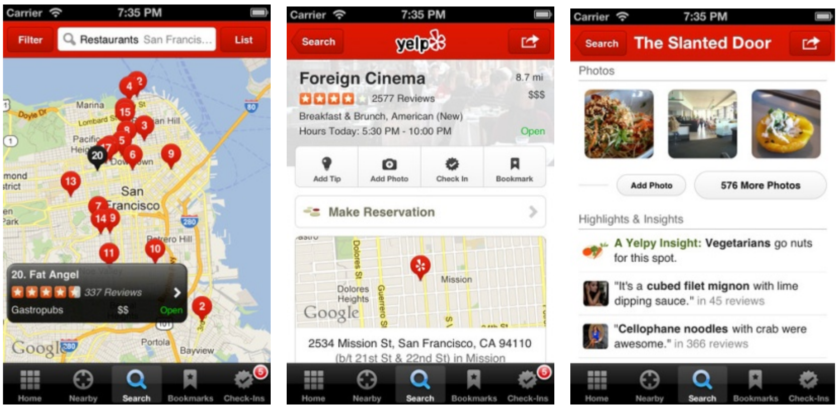

Figure 7: Examples of Yelp Screenshots

2.2.3.2.3 Picksie

Picksie is as location-based discovery service, pushing recommendations to user based on his profile, his past ratings, searches and reviews, his location, as well as current day, time and weather in his location. User choose the kinds of information he is interested in (concerts, happy hours, etc.) and Picksie dishes it out as it becomes available or as user get near a location.
Picksie takes user into consideration giving him a personalized experience. It filters out things which do not make sense – no dinner places at lunch time, no bars in the morning, no outdoor-only places during the winter and no places which are closed for business at the time. This reduces clutter, thereby helping user deal with his top choices effectively.
Picksie works only in New York and San Francisco right now.

Figure 8: An example of Picksie Screenshot

2.2.3.2.4 Tagwhat

Tagwhat is a mobile location-based guide. It is an original way to learn about the world around user through interactive stories, videos, and photos.
Tagwhat works to create context to location, providing video, pictures and narratives of where a user is. For example, more than just giving a restaurant review, Tagwhat provides pictures and a history of the restaurant.
Provided content is created by : (i) users that add content about a specific channel (heritage, music, sports, food, nature, art…), (ii) tourism organizations, universities, associated Press and other media organizations and (iii) open sources (Wikipedia articles on a location-related basis)

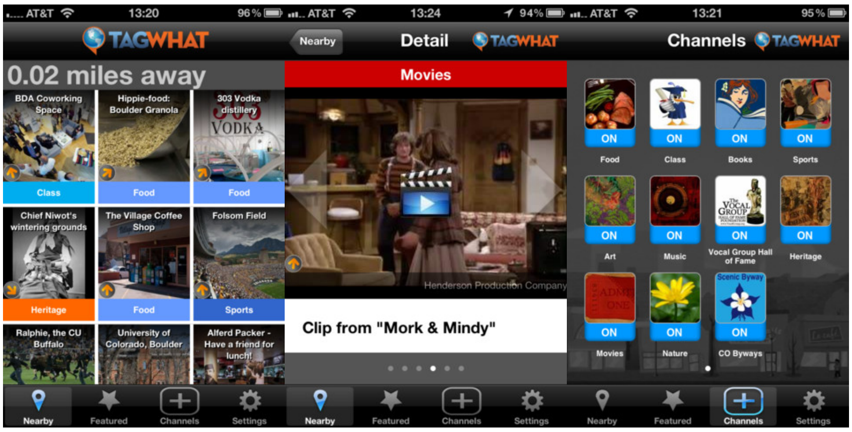

Figure 9: Examples of Tagwhat Screenshots

2.2.3.2.5 Darkslide

Darkslide's uses mobile device's location capabilities to bring user pictures from Flickr that were taken near him, so that he can see other photographers' take on the landmark in front of him.

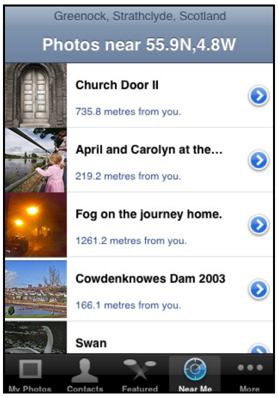

Figure 10: An example of Darkslide Screenshot

2.2.3.3. Location-based social networking and Augmented reality

Augmented Reality (AR) allows the user to see the real world, with virtual objects (computer-generated sensory input such as sound, video, graphics or GPS data) superimposed upon or composited with the real world.
This emerging technology is more and more used in several domains. In particular, travel and tourism industries have been very quick to pick up on it.

In this case of travel applications, AR is used to highlight information of important places and provide the connection between the real world and a useful knowledge, such as an historic event, meaning that this knowledge can be augmented onto current landscapes.
The use of AR in this area has enhanced the experience of users when they go travelling by providing not only information of the place they are but comments made by other users that have been there before. AR system in the travel context can connect different platforms to provide a richer experience to the final user of the system [6].
The idea of Location-based augmented reality is to point the mobile device's camera at a monument or other point of interest, and the application looks up what it sees in its online database. The screen shows what the camera sees, so it's like a window but with a heads-up display of additional information about what user is looking. It superimposes distances to points of interest, using the compass to keep track of where user is looking. User can sweep the mobile device around and scan the area for nearby interesting things.

This is the case of the travel guide application **Wikitude**. This application browses the world around user and provides information about places, famous landmarks, and other points of interest. The objects information is displayed in the camera right where the real object is located. It also locates users' friends (from social networks). Content in the Wikitude World Browser is mostly user generated.

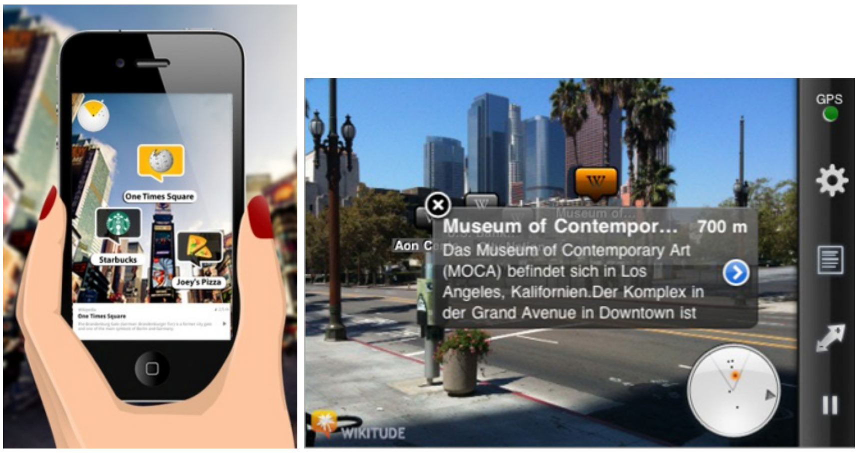

Figure 11: Examples of Wikitude Screenshots

Mobitour is another travel guide application that provides a direct view of reality enhanced with any information available in French touristic office databases. This added information can also be enriched with other users' comments and rates about the point of interest.

Figure 12: An example of Mobitour Screenshot

The mobile browser **Layar** takes this idea even further, proposing a framework for multiple layers of augmented reality content accessed through the camera of user mobile device. Layer identifies the user's location and field of view. From the geographical position, the various forms of data are laid over the camera view like inserting an additional layer. Existing layers include Wikipedia, Twitter and location-based services like Yelp, and tourist, nature and cultural guides.

More focused on social media, the **iPhone Twitter application** can find recent tweets near the user, so he can pick up the conversations going on around him.

Note that these applications are relying on GPS positions and therefore what AR proposes to user is information about what is supposed to be there, rather than what actually is. Real word is then augmented with some arranged virtual annotations surrounding each of the selected points of interests. Nevertheless, these applications, thanks to augmented reality and social media enrichments, are giving the traveller far more information than they have ever had.

2.2.4. Social Media Travelling in TWIRL

Information gathered from social Networks will be used in TWIRL to enrich the knowledge base of the applications by relevant information about a point of interest (monument, restaurant, activity, etc.). Results of opinion mining processes on the comments gathered from the social networks will be used by the recommendation engine to recommend to travellers some activities, places to visit, restaurants, etc.
Twirl application (Augmented Life demonstrator) will also propose to travellers to find all talks about a monument, a restaurant, etc. so that they can have different information or opinions about it.

2.3 Social TV

2.3.1. Introduction

The development of new technologies changes consumer perceptions regarding the television. The emergence of mobile devices leads to a large number of viewers to supplement the experience of watching classic TV shows with online information. This evolutionary change in how people consume TV shows, not only affects the way information is consumed but also where it is consumed. New technologies and mobile devices enhance the viewing experience with augmented information. Any mobile device that can display additional contextual information is called *second-screen*. The second-screen technology opens a number of new opportunities for distributors of content, advertising, television stations, platforms and operators, all entities wishing to exploit this niche market for secondary content.

The emergence of mobile devices are significantly improves the way users are consuming information. Currently, the ecosystem of applications is huge and constantly expanding. The Apple store for mobile applications has an estimated number of 775,000 applications. The Android market has around 700,000 applications. These devices enhance almost all types of activities, from the business up to the everyday challenges. Nearly 50% of U.S. citizens have a smart phone and a tablet, which means about 150 million people These are significant numbers and growth is almost exponential. A market projection estimates that during 2013, sales of new tablets and smart phones will exceed the number of existing laptops[3]. By 2020, mobile devices will become the main means for internet connection[4]. Cisco reports that the number of mobile devices will exceed the number of people this year and that by 2016 there will be 10 billion connected mobile devices worldwide[5].

These figures are representative for the entertainment community and they justify the effort to identify and promote new channels of communication for movies, television, advertising, or other media items. Although still based on traditional models, their functionality allows the creation of new market niches for advertising, embedded marketing, and merchandise.

Evolution of TV consumer behaviour is a current research topic. Depending on the type of content, consumers are beginning to have and to expect a certain kind of experience. The heavy users of mobile devices are very difficult to be pleased with just one classic TV show format. Three factors influence this:

- increasing the number of mobile devices owned by consumers with high technical knowledge,
- improving digital infrastructure, both within and outside the home or institution,
- digitization other activities in the life of a consumer

Consumers have become more technology literates and this is reflected in the way the TV content is consumed. Actions considered a few years ago *sophisticated,* as streaming online the TV content and the purchase of digital content, are now common. In addition, homes that have multiple TV screens and various mobile devices permanently connected, it becomes commonplace. Over 80% of UK homes now have access to the Internet in which over 61% of WiFi enabled. In 2011, there were over 39 million mobile broadband connections from smartphones or tablets[6]. Many aspects of consumers' lives are almost entirely digitized. Video and audio content can be consumed everywhere, social relations have entered the era of social networking, books and

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[3] Samsung Romania
[4] Report: http://www.pewinternet.org/Reports/2008/The-Future-of-the-Internet-III.aspx
[5] Report: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html
[6] Report: http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr12/

entire libraries have been digitized and can be accessed from anywhere through mobile devices, online banking is piloted, any product can be ordered directly from mobile, traditional newspapers have been digitized and new forms of communication like Twitter has appeared. Now, the consumers have easy access at the technology and they can use wherever they are. The following figure presents an overview of the consumer behaviour during TV broadcasts. Viaccess-Orca is a synthesis from the information provided by Nielsen Research, Torsion Mobile and PewInternet:

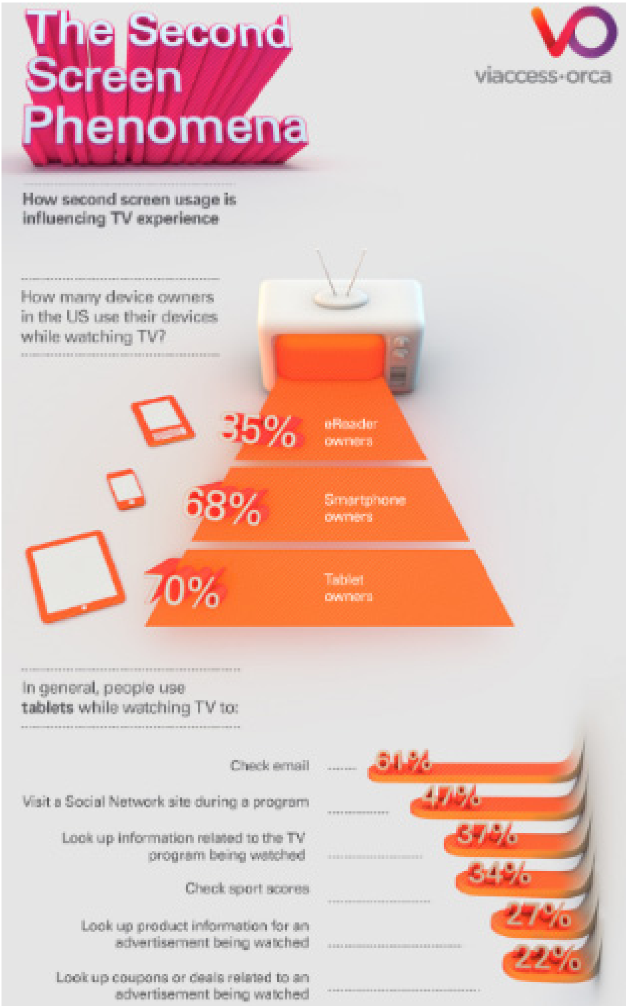

Figure 13: Infografic on the usage of second-screen during TV Shows

This change in consumer behaviour and technology landscape has led to a simultaneous increase in the use of devices as we watch TV. When the TV show does not provide the expected experience, the consumer attention is turning to other types of information, social or digital encyclopaedias. In the context of these technological changes, mobile devices and smart TVs are offering straightforward ways to find additional information. The media industry is now able, perhaps more easily than ever, to understand the consumer behaviour. The public has shown that it is willing and able to engage with web content and additional services that meet their expected quality. The following figure presents a graphic of consumer activities during TV broadcasts:

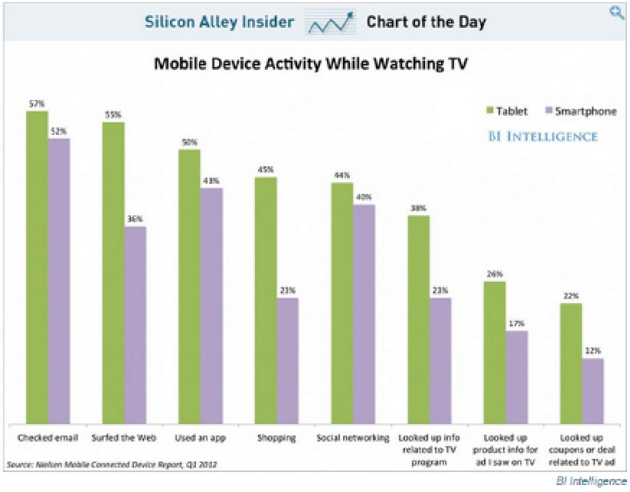

Figure 14: Graphic of consumer activities during TV broadcasts

Television has always been a social environment, primarily in the residential environment and then in public places. Major sporting events are an example of social TV with both family and friends. Virtual socialization gained momentum with the advent of Twitter service. Twitter indexes words that begin with the symbol #, named *hashtag*. Such words are promoted for both TV and commercials. Anyone sending a message with a hashtag becomes an active part of the community. Currently, there is an entire ecosystem formed around these keywords.

Several statistics show that the number of related messages sent during TV shows is increasing:

- During Grammy awards ceremony, which took place on February 10, 2013, there were over 13 million Twitter conversations with a peak of 160,341 messages per minute. The intense activity took place during the award ceremony Jay-Z - 116,400 messages per minute and offered live song Rihanna - 114,800 messages per minute,
- During Super Bowl event there was registered a record of 4064 messages per second. The following figure is the correlation between different times and number of posts:

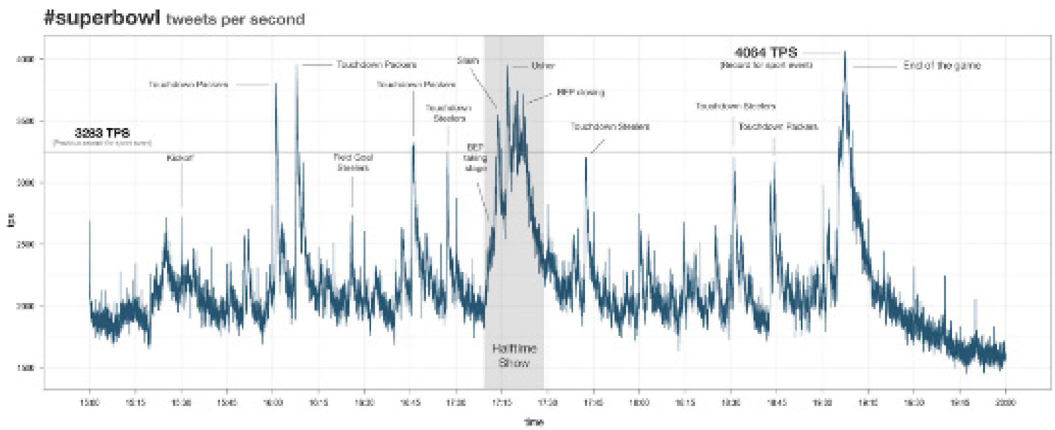

Figure 15: Correlation between different times and number of tweets

- According to Carri Bugbee Agency, the hashtag #TrumpRoast was used more than 27,000 times on Twitter during the broadcast TV in March 2011,
- The TV show X Factor has averaged 94,000 social commentary per episode

According to a recent study by Microsoft and Wunderman, 69% of consumers using second-screen technology feel that access similar content using various screens make content more useful, relevant and informative.

Socialization involves interaction between consumers during TV shows. This allows media networks to analyse how people look and consume media information in ways that were not possible before. Currently, networks like Discovery Channel engage in conversation with the audience and fans over different types of programs. Media Trust manages over 70 Facebook pages with over 40 million fans and 20 Twitter accounts with over 2.4 million followers. The strategy of using social networks comprising the following steps:

- building relationships and engaging with fans,
- customizing brand,
- strengthening relations with talent fan,
- maintaining contact at all times

One of the most successful social media campaign is the promotion of Shark Week Discovery show. During one week in July 2011, there were more than 750,000 tweets. This represents an increase of 8 times the number of posts compared to 2010. Twitter channel @SharkWeek increased to almost 60,000 fans. Currently, there are 94,877 fans.

2.3.2. Existing platforms and Solutions

Approximately 80% of those who own a mobile device or a laptop are using it while watching a TV show. Most online activities are email checking, texting and chatting, updating status on Facebook or Twitter, activities that not directly connected with what is happening in the TV show. The aim of SocialTV technology is to create an application that captures and redirects the watcher's attention to new dimensions of the TV show. As an example, Zeebox[7] announced on February 12, 2013 that it will implement a new feature called SpotSynch which allows providers to add content linked to TV commercials.

Most SocialTV applications requires registration. This step is important for capturing statistical data about the consumer. It also allows viewers to form discussion groups around a TV show. Marketers can analyse consumer behaviour in such networks and then run targeted marketing campaigns. Ads can be added by producers of content and targeted only to those interested. SocialTV technology allows media trust advertisers, content providers, production companies to provide a value-added viewer experience that enhances TV viewing experience of the show.

Some of the most popular second-screen applications are Miso[8] and GetGlue[9]. These applications allows the viewer to become part of the TV show community. Because applications are not synchronized with TV shows, users can participate in the discussion even outside of the broadcast. Both applications have the ability to communicate with Facebook or Twitter communities and offer to users the ability to interact with others who share a similar interest.

SocialTV technology allow other actors besides the traditional ones to develop specific applications. For example, the Disney Second Screen[10] division develops specific applications for animated films. The mobile apps are synchronized with the film running on the Blu-ray player and offers additional and interactive content.

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[7] http://zeebox.com/tv/home
[8] http://gomiso.com/
[9] http://getglue.com/feed
[10] http://disneysecondscreen.go.com/

Miso platform, in partnership with DirecTV and AT&T U-verse offers a fully synchronized experience with the ongoing TV show. The viewer could create its own content displayed at specific points of time during the show. Synchronization is ensured through specific identification technologies like audio watermarking or video fingerprinting. The GetGlue platform contains not only TV shows, but also music, movie trailers and books, so that users can exchange views and feelings about a wide range of multimedia content. Comcast has a company called Tunerfish that combines online viewing multimedia content with socializing on Facebook, Twitter, YouTube, Google Plus and many other social networks.

Such platforms are an extremely powerful marketing tool for producers of music, film and television, publishing or any commercial company operating in the media space. Media analysis and rating companies such as Bluefin (recently acquired by Twitter) offers a wealth of statistical tools vital for media trusts. Integrating digital technology gives viewers an experience that has failed so far to be delivered by classic television. Specific SocialTV applications allow real convergence of different information channels and immersion of the viewer into the world of media.

Currently, there is no standard terminology for the various ways to use the second-screen and SocialTV technologies. The terms are often used in a different ways from one platform to another. Analysing various configurations we can define the following terms for augmented entertainment domain:

- Second-screens - refers to any activity involving the use of a second screen while watching a TV show. Users can check the weather, news, sports results etc.
- Synchronous activities - refers to specific activities during TV show. Activities are triggered by specific moments of time or elements from the TV show. Some common examples are voting applications, questionnaires, public debates, etc..
- Augmented experiences - refers to applications made specifically for a certain TV show. They typically provide additional content, interactive and aimed at keeping the attention of the viewer as much time on that content.

These terms are not very strictly delimited. A general second screen activity like discussions on social networks could become a synchronous activity with the start of the TV show. In addition, the social network discussion flow may be included inside the special crafted mobile application in order to augment the experience. In the case of synchronous activities, Twitter has succeeded in providing a direct link between the media industry and communication of messages by keyword or hashtags. To cover a specific topic, users of Twitter are using hashtags. A search for a hashtag returns all messages containing it. Twitter has found that using a specific hashtag during a show or TV advertisements lead to an increase in the number of comments on the subject. Some media campaigns are rewarding users who use specific hashtags during the show. Adidas has developed a media campaign across all channels of communication around the hashtag # takethestage.

Figure 16: Adidas campaign is using #takethestage hashtag

Mercedes has designed a TV campaign that immerse the spectator into the storyline. The viewers are able to use specific hashtags like #evade or #hide to change the story of the show.

Figure 17: Changing the storyline during Mercedes campaign

Twitter has found that there is a close connection between the TV show and the number of messages sent. For example, during the TV show XFactor 2012, it was proved that the number of messages is a barometer for the finalists.

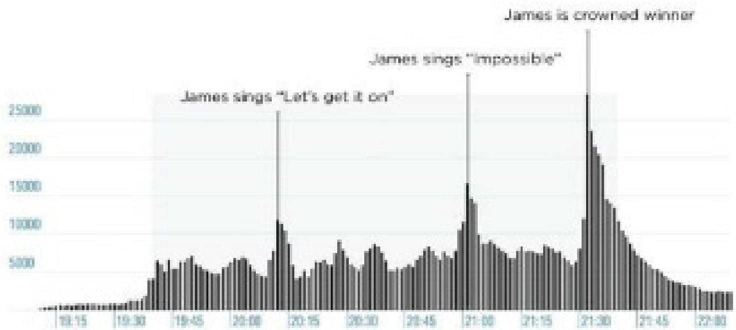

Figure 18: The number of tweets indicates the finalists

Each type of TV show has a specific graph of the number of messages. The media companies know exactly when and what type of content to convey. The following figure shows the differences between the various types of TV programs.

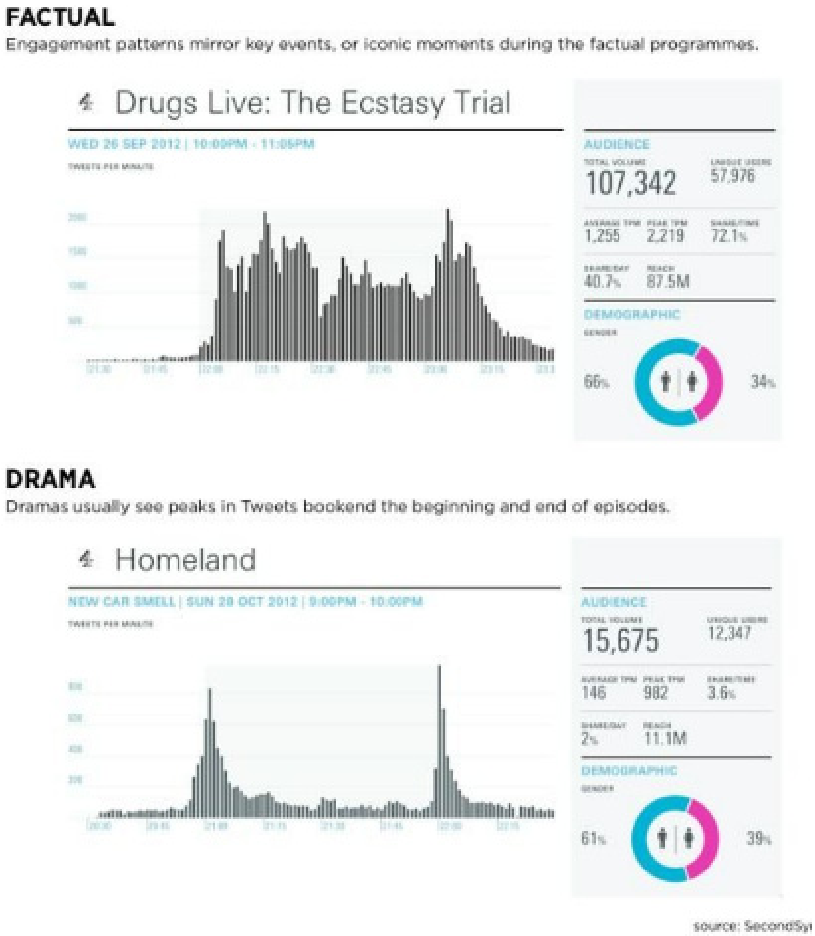

Figure 19: Different types of message distribution depending on the TV show type

To recognize TV show or the content therein, second-screen platform are using digital signature techniques for recognizing audio or video. There are two main methods for detecting the exact position in a TV show:

- Audio watermarking - consists in analyzing the audio signal to find the positions where it could be hidden a digital code without affecting the original sound quality. The main advantage of this technique is that a TV channel or a content owner can encrypt additional data inside de audio channel, making the exploitation impossible by other manufacturers. Data injection is performed at short intervals, 2 seconds or less, providing a good precision,
- Video fingerprinting – it consists first in building a fingerprint, a signature, of the audio source and store it in a database. Customer's mobile device captures the audio source for about 5-10 seconds, in order to compute the fingerprint mark. Once the fingerprint is computed, it is sent to the fingerprints database for identification. This technique has the main advantage that it could be used not only by the content owner, TV channel, or TV studio, but also but third party services to mash-up new products. This technique has many drawbacks: there must be a strong infrastructure to identify signatures, by using only the signature it is not possible to identify the source distribution, multilingual content needs more signatures, and there must be a priory access to broadcast content to generate new signatures before broadcast,

Currently, there are few platforms for audio encoding and detection:

- Civolution VideoSync –the platform provides developers with a suite of SDKs for different mobile platforms. The watermarking process use DAW88 hardware supplied by Axon. Various products such as ExMachina use the VideoSync platform for The Voice of Holland and Germany's Top Model television shows and by Miso platform for Dexter TV series,
- Nielsen Media-Sync - because of the extensive experience of audience measurement, Nielsen firm platform designed for second-screen is one of the most complete. The platform implements a Software as a Service paradigm, and includes a suite of content management modules, application server, analysis and reporting engine, and programming interface. For audio watermarking it uses dedicated hardware like NWE-3G produced by Ross Video. Currently, the platform is used in various shows and series like My Generation, Grey's Anatomy or the Weather Channel from ABC Networks,
- Shazam for TV – the Shazam platform is the music recognition leader on mobile devices. The company tries to bring the same technology on the TV entertainment side,
- Technicolor MediaEcho – is specialized in dedicated platform development for live shows, Video on Demand (VOD) and BluRay media. The technology is used by the Media FOX series Sons of Anarchy

Other platforms are also gaining market share: Yahoo IntoNow, Zeebox, Zeitera, Ensequence, TvTak, Never.no etc.

Recently, the second-screen ecosystem has become increasingly complex. Media trusts such as BBC, ABC, CBS, MTV and from Romania, Intact Media, CME - Central European Media Enterprises are the most influential actors who create content. To monetize the created content, the media trusts are selling advertising space and media content to service providers. National or local suppliers offering local advertising can sell advertising space to advertisers. Content can be sold also to cable companies, satellite, and telecommunications providers. Price is influenced by the market value of the trust and the number of the service subscribers. Usually media trusts have more channels and programs that are sold in packages. Media services providers are enforced to buy such packages to not lose customers. Moreover, media trusts require the suppliers to not block or remove channels. For this reason, grids contain a huge number of TV channels; many are not interesting for the consumer. Emergence of second-screen technologies requires providers to adapt to the new media perspective. There are signs of the emergence of virtual providers located exclusively within the Internet, offering similar TV services with a simple network connection.

Media service providers such as Verizon, Comcast and from Romania, UPC, RCS-RDS, Romtelecom do not provide a single service. Subscribers receive the package for both television and Internet and telephony in some cases. The delivery of content to any device is limited by legal reasons. Media trusts prohibit duplicating media content on multiple devices. In a single subscription, the content can be viewed only on one TV. In a house, the configurations with multiple televisions are outside the scope of the media providers. At CES 2013, company Dish Networks presented the Slinghopper platform that allows relaying incoming TV content to mobile devices over the internet. Over The Top services like Netflix, Hulu and from Romania, Voyo.ro, vPlay.ro are broadcasting directly through the internet service. It is expected that OTT sites will collaborate with service providers and their offers will be included in the overall subscription offers. RDS-RCS and UPC subscription offers the possibility to choose for Voyo.ro. Providing OTT services in this way eliminates the need for another device attached to the TV.

The SmartTV market is also overcrowded with offerings from Samsung, LG, Sony, Philips, Toshiba, Sharp TV makers. The main target for SmartTV platforms is to eliminate the existence of other specialized equipment while providing much richer experience. Currently, Samsung SmartTV technology has the largest market share. Only in Romania, last year, were sold over 700,000 SmartTVs, representing approximately 78% of the specific market. In Germany were sold, in the same period, more than 9 million devices. Samsung's SmartTV technology is different from other competitors. The software platform is a Webkit based browser running the Javascript code of the application. The TV features are exposed through a Javascript API. In this way, any web developer is able to write apps for the TV. In addition, almost any website can be adapted to TV viewing. Samsung offers a well-developed ecosystem for SDKs and development tools. Samsung products, regardless of their type, communicate consistently.

2.3.3. Social TV in TWIRL

The Social TV component in TWIRL aims to augment the TV content, watched in a home environment with interactive educational content. The project will:

- Promote the concept of personalized edutainment (educational entertainment) by including multimedia educational content from various sources in order to individualize the entertainment information,
- Facilitate the participation and involvement by creating micro-communities around educational programs on TV.

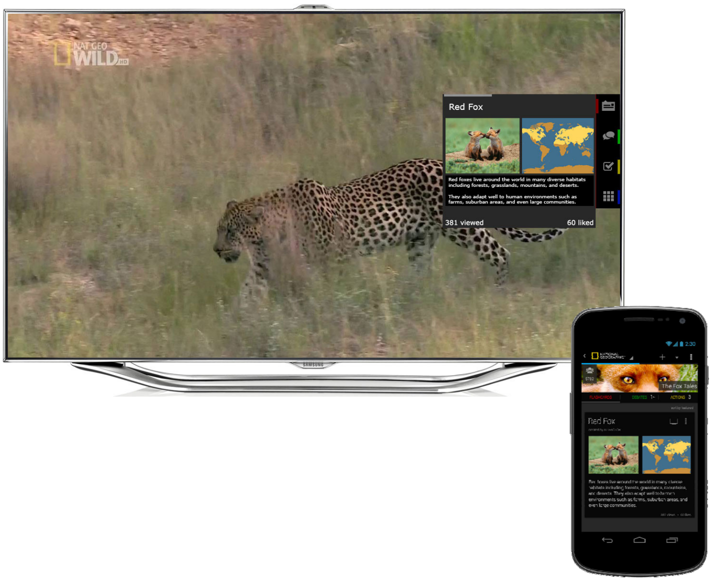

Figure 20: Educational content displayed during National Geographic Wild show

The SocialTV component of the TWIRL project, addresses all segments of age, and the platform will be used both by children and elderly. The main components of the platform are:

- SmartTV and tablet - the application will allow the tablet to display relevant information to the current TV show, in a summarized format. Depending on the type of program and profile, the information displayed will be different. The information can be synthesized from any educational content, from a simple questionnaire to complete courses, hosted by LMSs (Learning Management System). The application has connectors for different eLearning platforms. The identification component of the application will identify the show and its main features. Recognition can be achieved simply by parsing the TV Guide to more complex methods like fingerprint recognition algorithms for audio or video.
- Web application platform for configuration, management and statistics – the web application allows users to configure the information content developers will display on the second screen. The application contains a semantic database, which will provide contextual information. Information that will populate the database could come from various databases such as Freebase, IMDB, Wikipedia etc. In addition,

the mechanisms of communication between users, publishing messages to other social platforms, ad hoc communities will be developed under this component.

3 DATA GATHERING AND ANALYSIS

3.1 Introduction

In this section we explore the methodologies that we are going to use in this project. There is two main methodologies i) Web base crawling and ii) OSN Crawling.

The first one is mainly going to be used for crawling resources that contains information about tourism industry such as trip advisor and other similar portals. The second one is about the methodologies that we will use to gather the social information from online social networks.

Lastly in this section, we overview the data mining techniques to investigate the gathered data both from web crawling part and OSN part.

3.2 Web Crawling & Focused Crawling

A crawler is a software which traverses the Web, collecting pages and resources. It exploits the graph structure of the Web to move from page to page through outgoing links [69] [93]. Each explored page is collected, converted into plain text to extract the contained links, and indexed.
Crawlers are also called robots or spiders. Usually, search engines employ crawlers to collect pages in order to provide up-to-date results to a user query.
The enormous growth of the Web in recent years has made difficult the discovery of sources on a given topic. Search engines do not always successfully provide sources adapted to the user needs. Focused crawlers are an alternative to search engines which can address this problem. Contrary to standard crawler, a focused crawler explores the Web and collects resources according to the user needs. In section 3.2.1, we present web crawling approaches in general and then we present a survey of focused crawler approaches. In section 3.2.2, we describe two known web crawling tools.

3.2.1. Current techniques

3.2.1.1. Web crawling process

A standard crawl process is made of several steps. These steps correspond to specific sequential tasks.
Initially, the crawler collects all pages pointed by a set of starting URLs called *seeds*. These URLs are used to construct the exploration *frontier*, in other words, the list of URLs to visit.
During the exploration process, the frontier is updated by receiving new URLs extracted from collected pages. The limit of added URLs corresponds to the maximum number of URLs to explore or to a distance, called *deep exploration*, between seeds and discovered URLs. This exploration cover (the *scope*) may also correspond to a maximum number of pages to be collected or to a predefined exploration time limit.
Once the scope is defined, the crawler runs, for each URLs of the frontier, an *exploration task*. This task is described in Figure 21.
If no limit is set, the crawler can crawl indefinitely and collect the full Web.

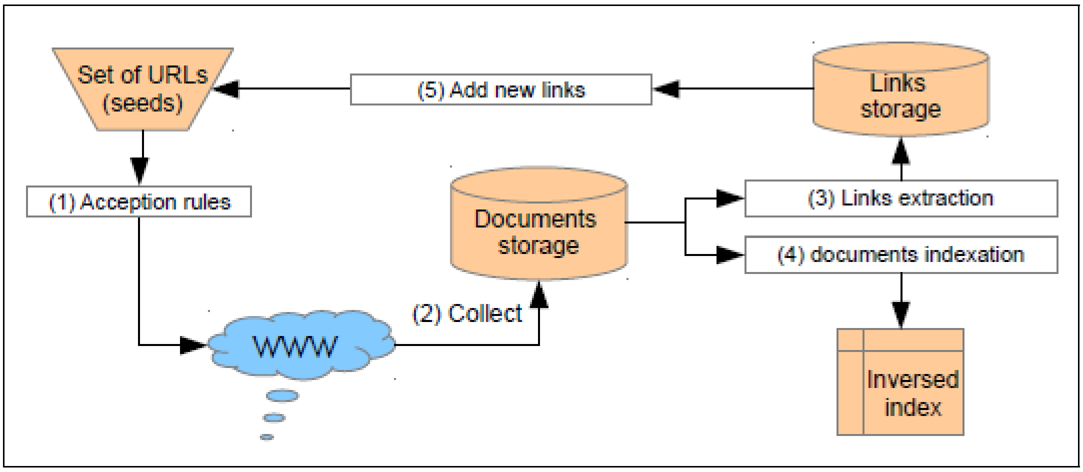

Figure 21: The exploration process of a crawler

In order to increase the speed of the exploration task and to avoid waste of unused resources, the crawler can explore several URLs simultaneously. The frontier can contain several queues of URLs to explore (for example, a queue per host) and can be configured to set a priority for each queue. Each URL of a queue can also have a priority.
In order to sort URLs and queue, priority rules must be defined during a configuration task, before the exploration.

3.2.1.2. Web crawling strategies

Collecting a large part of the web, collecting up-to-date information on a specific subject, monitoring pages on a given thematic- there are many reasons that justify a web crawling. And these reasons influence the choice of a strategy of crawling.
In addition, the constraints related to the dynamism of the Web, whose content changes constantly, should be considered in a crawling process. Indeed, billions of documents are available on Internet, and keeping the freshness of collected pages is very difficult.

Sigurosson [78] distinguishes two kinds of strategies:

- The first strategy allows the crawler to explore a page only once. When a page is rediscovered, it is ignored. A large part of the web can be quickly explored with this strategy. This is a useful strategy to explore a specific part of the Web during a defined time interval.
- The second strategy is an incremental strategy. It offers to the crawler the possibility to monitor a part of the Web: when a page is rediscovered, it is re-injected into a queue of the frontier. Queues are never empty and the exploration continues indefinitely.

A well known strategy of web crawling is the **breadth-first search** (BFS) [65] which is a graph traversal strategy. The BFS begins at a seed and inspect all is outgoing links. Then, for each page pointed by those links, it inspects and explores their outgoing links which were unvisited, and so on.
This strategy is different from the **depth-first search** which begins at a seed and explores the first outgoing link and continues along each branch before backtracking.
Crawlers are different according to their strategy of exploration but also according to their collecting approach. Focused crawlers, for example, collect only relevant pages according to a specific need by focusing their exploration [78] [55]. They are described in more details in the following section.

3.2.1.3. Focused crawling strategies

Traditional crawlers explore Web pages from a set of URLs and convert them into plain text to extract the contained links. Those links are added to the URLs queue in order to crawl other Web pages. A focused crawling system exploits additional information: the hyper-textual information from Web pages such as anchors and text surrounding the links. This information is used to predict if the page can be relevant, i.e. if it matches with user interests. For example, focused crawlers can reject child pages using anchor text of source URL which provides information about child pages content [25].

3.2.1.3.1 Topical locality phenomenon

According to the topical locality phenomenon [25] Web pages on a specific topic are connected one to another. Focused crawlers are based on this phenomenon and crawl clusters of pages each time they find an interesting one. Therefore, the two famous algorithms, *PageRank* [12] and *HITS* [49], based on the structure of links, are really effective. They are often used to assign a hypertextual-based rank to seeds to be explored.

- The PageRank algorithm is used by Cho [21] to give scores to pages downloaded so far. These scores are then used to define a priority of URLs extracted from pages. The PageRank is calculated on a very small subset of the Web so the improvement is not large. Furthermore PageRank algorithm is too general to be used use in topic-driven tasks 60] [61]. However, pages on a same topic can be connected to a same off-topic page. Bergmark, Lagoze and Sbityakov [7] allow the crawling process to explore a limited number of off-topic pages in order to find the next relevant one. This technique is called *tunnelling*.
- HITS (Hyperlink-Induced Topic Search) is also known as hubs and authorities [49]. It is a link analysis algorithm that rates Web pages following the idea of backlink count that assigns a rank to a page according to its popularity. The popularity of a page is the number of pages pointing to it. In more sophisticated algorithms, the importance of pointing pages is recursively taken into consideration. A hub page is a page that pointed to many other pages, and an authority page is a page that was linked by many different hubs. This algorithm can be used to extract pages particularly significant from a thematic graph known. This result can be interesting for a crawler to extend the known graph on a thematic. For example authority pages can be analyzed to enrich the initial description of the thematic and next links from hub pages can be chosen to be explored in priority [95].

3.2.1.3.2 Fish search

One of the first works on the subject of focused crawling is the fish search. It was proposed by DeBra [26] [27] which simulated in his approach a group of fish migrating on the web. Each URL corresponds to a fish whose survivability is related to the relevance of the visited page. Page relevance is estimated using a binary classification by a means of a simple keyword or regular expression match: a page is relevant or irrelevant. A fish die off after traversing a specified amount of irrelevant pages. On every document, the fish produces offspring according to the relevance of the page and the number of outgoing links. The number of fish is more important in the general direction of relevant pages which are then presented as results.
The *Shark-search* approach [42] is based on this algorithm. It provides a priority to pages to be explored according to a linear combination of source page relevance, anchor text and neighbourhood of the link on the source page and inherited relevance score. Contrary to the fish search algorithm, page relevance is a measure of similarity between a page and a query in vector space model. This measure can be any real number between 0 and 1.

3.2.1.3.3 Use of background knowledge

Chakrabarti, Van den Berg and Dom [16] propose a focused crawling system which makes use of both a classifier to evaluate the relevance of hypertext documents according to a specific topic, and a distiller to identify hypertext nodes that are considered as good access points to other relevant sets of pages to collect. Chakrabarti uses pages in the Yahoo tree taxonomy and seed pages to build a model for classification of retrieved pages into categories. A category corresponds to a node in the Yahoo tree.
The system consists of three separate components: crawler, classifier and distiller. The classifier is used to determine page relevance according to the categories it belongs and the model. Outgoing links to explore by the crawler are ranked according to the classifier results. The distiller subsystem identifies hub pages using a modified HITS algorithm [49]. Top hubs are then marked for revisiting. A constant average relevance between 0.3 and 0.5 (averaged over 1000 URLs) is shown with this approach. Without focused crawler approach, the quality of results almost immediately drops to practically 0.
Ehrig and Maedche [30] provide a Web Semantic approach by considering an ontology instead of the Yahoo tree for page relevance computation. After pre-processing, entities (words occurring in the ontology) are extracted from the collected page and counted. Relevance of the page with regard to user interest, which corresponds to a list of entities, is then computed by using several measures on ontology graph (e.g. direct match, taxonomic and more complex relationships). The harvest rate is improved compared to the baseline focused crawler (that decides on page relevance by a simple binary keyword match) but is not compared to other types of focused crawlers.
Multi-agent approaches use a population of agents based on artificial life models. Agents are autonomous and in competition. Each agent has an energy level that varies: it falls for each action and increases when a resource is collected. The purpose of an agent is to survive by finding resources. The life of an agent is characterized by two energy thresholds: a threshold of death and a threshold of reproduction. The goal is to discover the rich areas of resources identified by agents who will instinctively focus their actions in these areas to survive and also to reproduce.
This approach has been adapted to the discovery of Web sources. Menczer & al. [62] transpose this model to a crawler as follows:

- Agents are crawlers.
- Agents consume their energy in browsing the Web from link to link.
- Agents gain energy according to the relevance of Web pages they find.

The agents' goal is to survive, so they try to limit their actions. The population of agents balances itself due to dead and reproduction; that's why the network is not satured. Most relevant areas of the Web are identified by the way of a large number of agents in those areas.
One of the most renowned adaptive focused crawlers, called InfoSpiders, is based on this approach. It's a crawler based on the ARACHNID approach for Adaptive Retrieval Agents Choosing Heuristic Neighbourhoods for Information Discovery [61]. This approach uses a genetic algorithms and reinforcement learning.
Agents are able to measure the relevance of a page based on a given user query and to select the next page to visit. The agents are built using a genotype determining their search behaviour. The first component of this genotype is a parameter that represents the extent to which an agent trusts the textual description about the outgoing links contained in a given page. The other two parameters are a set of terms T of the given query and a vector W of real-valued weights, initialized randomly with uniform distribution. For each link, an agent extracts the set of keywords that appear around it and that are also included in the genotype set. The *in*() function is used to calculate the weight of these terms according to their number of occurrences and their proximity to the link. The goal is to determine the terms which best discriminate a relevant document according to the user query.
The choice to explore a link is based on a stochastic process; however, the relevance of the explored page is calculated and compared with the predicted relevance. This comparison allows to change the weight of the terms in the agent's vector W according to a back-propagation of error [75]. Two functions *benefit*() and *cost*()

update the energy of the agent. The first determines the energy gain by measuring the number of known terms in the new visited page. The second function consumes energy depending on the size of the page and its response time.

My Spider [67] is an online Java application based on this approach[11]. This application provides real-time information about each agent during the collecting task.

Chen Chung, Ramsey and Yang approach [19] is similar except that the crawl is a Best-first exploration. In this system, called Itsy Bitsy spider, an important functionality is missing: the agents are not autonomous and they are not able to evolve during the discovery task.

3.2.1.3.4 Reinforcement Learning-Based approaches

Chakrabarti, Punera and Subramanyam [14] use textual information contained in pages that point to the ones to be evaluated during the download. Their work is based on a traditional focused crawler: a classifier evaluates the relevance of a resource according to the chosen topics. The enhancement of the crawler concerns the frontier. A priority is assigned to unvisited URLs by extracting features from a particular representation of the pages that point to unvisited URLs. Basically, for each retrieved page p, the apprentice is trained on information from the original classifier and on some features around the link extracted from crawled pages that point to p. Those predictions are then used to calculate if it is worth traversing a particular URL, and therefore order the queue of URLs to be visited. The evaluation shows how the false positives decrease significantly between 30% and 90%.

3.2.1.3.5 Conclusion about focus crawling approaches

Focused crawlers can collect a portion of Web according to a specific need of information and can avoid seeking information on a too large set of pages. In this chapter, approaches which exploit the structure of the Web to determine the relevance of a page have been described. These different approaches are difficult to compare, mainly because of the difficulties to evaluate a crawler. However, they take into consideration different parameters and different needs. The Fish search approach [26] uses an explicit request representing the need of information whereas [30] were interested in a more comprehensive definition through ontologies.

Other approaches have improved their methods using the structure of the Web and metrics [15] [29] to not focus only on the user needs. Reinforcement Learning-Based Approaches are particularly suited to the Web and these changes. Their advantages are particularly customized considering the needs of the user, especially if it needs changing.

3.2.2. Existing Platforms and tools

Among the few number of existing focused crawling platforms, it's worth mentioning *My Spider* [67] which is an online Java application based on the ARACHNID [61] approach[12]. This application provides real-time information about each agent during the collecting task. Focused crawling approaches are developed on specific system or based on existing crawlers that are adapted to focus their exploration. There are a number of crawlers as Heritrix, Nutch, JSpider, YaCy and Crawler4j. These crawlers are distinguished by their license, their programming language or their architecture. Heritrix and Nutch are particularly interesting due to their adaptability: they are open source and their functionalities can be extended.

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[11] http ://myspiders.informatics.indiana.edu/
[12] http ://myspiders.informatics.indiana.edu/

3.2.2.1. Heritrix

Heritrix is an open-source Java crawler which is still actively being developed. As Heritrix is published under the GNU Lesser General Public license (LGPL) it offers free access to the full source code of the project. It follows a highly object-oriented modular design. This feature allows the developer to change or add source code in an easy way.
There are mainly three basic concepts on which Heritrix is built:

- Scope - The Scope is used to determine which URLs are taken into account or are ignored for a crawl. This can be modified to order URLs to visit and also to focus the collect.
- Frontier - The Frontier handles the URLs which are scheduled and need to be collected. It also handles URLs that already have been collected. In a focused crawling approach, the Frontier can be modified to filter URLs to lead the collect.
- Processor Chains - The Processor Chains includes so called modular processors that execute specific actions in a special order on each of the scheduled URLs.

3.2.2.2. Nutch

Nutch is an open-source Java Web search software based on Lucene[8]. It is published under the Apache License that is open source and offers full access to its source code. Similar to Heritrix, Nutch offers a highly object-oriented modular design and is easy to extend by own plugins or modules.
Basically the crawler fetches Web pages according to settings and plugins chosen by the user and writes them to an index. A specific plugin can be developed to lead the collect and focus the exploration.
Contrary to Heritrix, Nuch consists of a crawler and three others components: the WebDB, the Indexer and the Search Web application [68]. The following list shows the purpose of the single components:

- Crawler: explores the Web and collects Web sites.
- WebDB: database that stores known URLs and the content of collected Web pages.
- Indexer: parses the database and builds a keyword-based index.
- Search Web Application: a Web search user interface.

The choice of a crawler platform generally depends on the collecting task to be performed. When the goal is to collect a small part of the Web, most of crawlers are sufficient. The choice of the presence of an index is justified by the use of a search engine after the collect task. To collect large collections of documents, the use of YaCy with peer2peer is an interesting solution: speed does not matter here, the interest lies in its simple and distributed architecture. Finally, for raising medium-sized, fast and reliable, we will prefer Nutch and Heritrix especially for the reasons mentioned above.

3.2.3. Use of Web Crawling in TWIRL

In TWIRL, an approach which provides to the system new relevant sources of information according to specific needs will be introduced. This approach aims at combining a personalized crawler with a collaborative filtering system. A more complex representation of the needs will be used in order to focus on relevant pages during the exploration task. The goal is to feed the crawler with new starting pages.
A specification and an implementation of an optimized focus crawler that is able to gather big data or a part of the Web (according to the specific needs of TWIRL) will be proposed.

3.3 OSNs Crawling

Current online social networks are mostly containing profile of their users including their information in addition to their social relationships.

A social networking service is an online service, platform, or site that focuses on facilitating the building of social networks or social relations among people who, for example, share interests, activities, backgrounds, or real-life connections. A social network service consists of a representation of each user, his/her social links, and a variety of additional services. Social networking sites allow users to share ideas, activities, events, and interests within their individual networks. The main types of social networking services are those that contain category places (such as former school year or classmates), means to connect with friends (usually with self-description pages), and a recommendation system linked to trust. widely used worldwide social networks area are Facebook, Google+, and Twitter. Base on the amount of information that a social network can allow the user put in the profile and the privacy policy of that network, crawling methodology will be different. Here we explain the techniques that are available to gather this information from the social networks.

3.3.1. Current techniques

As nowadays online social networks has an important effect on everyday life of many people in the world and also these kind of network provides many information for study the behaviour of users as well as other features, gathering information from these networks is a popular topic for research. By the gathered data, many research area direction will be appear such as Social Sciences, Marketing, Large scale data mining and privacy, etc.
There are several research works that explain the current methods. Authors in (Gjoka, M., 2011 [231]) present a comprehensive study on the usual current crawling techniques with comparing these methods and study the pros and cons of each one. In other work of these authors (Gjoka, M, 2010 [232]), they present techniques for crawling Facebook as most popular social network.

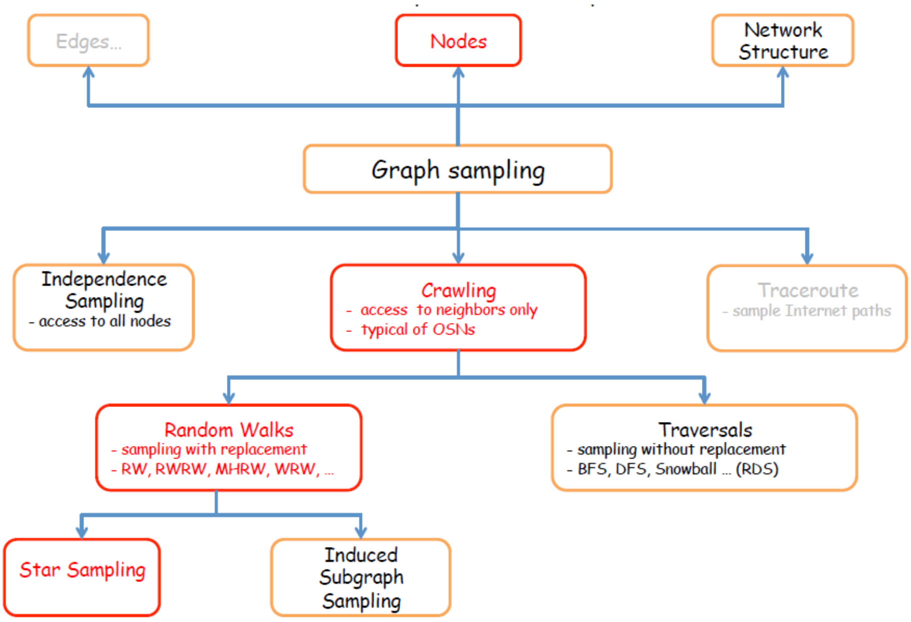

Figure 22: The exploration process of a crawler (Gjoka, M, 2010 [137])

Most current techniques regarding to gather social network's information can be categorized in different categories. Figure 22 shows some of the different categories of crawling with goal to obtain a representative sample of the social network. As it is illustrated in this chart in the crawling methodology, two main method is popular: Random walk way and Traversals crawling.

The first method is random walk way of crawling that is gathering samples of network information with doing replacement. Here there are several strategies to follow such as RW, RWRW (Re-Weighted Random Walk) and MHRW (Metropolis-Hastings random walk).

The second method is traversals crawling with different strategies like BFS (Breadth-First-Search) and DFS (Depth-First Search). The main difference between BFS and DFS is the steps that we follow to select next node to visit. Figures 23 and 24 show the example of BFS and DFS searching methods. The numbers shows the steps that need to be follows to do a search and same is for crawling procedure.

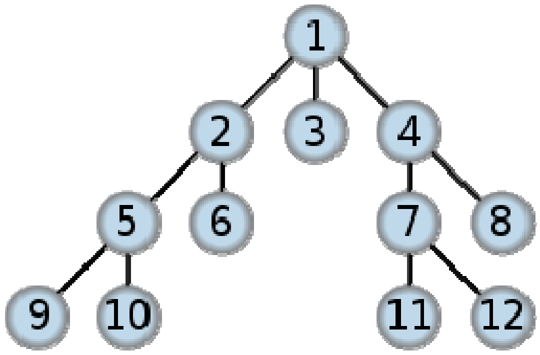

Figure 23: BFS Example

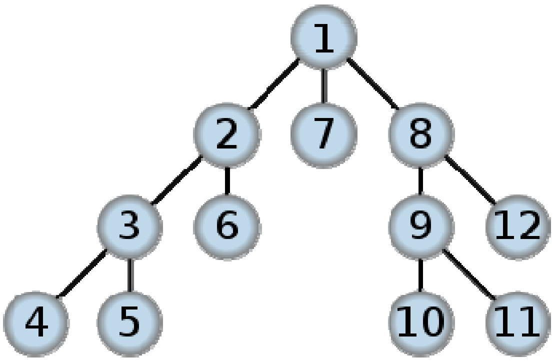

Figure 24: DFS Example

Each of these strategies can be applied base on the target network and the required information that need to be crawled. For example if we want to gather all the connectivity information of the one Facebook profile including the friendships, we can make do this by using a BFS method and start from the root user and go step by step to all friends (connections) of the root users, later on for expanding the crawling domain we will go to the friends of the fiends and start again crawling with considering each of the friends as root users.

3.3.2. Existing Platforms and tools (Case of Facebook)

Two popular way of crawling that many of previous work has been done base on them are web base crawling and API.
The web base crawler is simply goes to the web pages of profiles or other targeted pages and gathers the information that is available in the web page. There are several ways of doing this crawling process and also base on the policy of the website the methodology is different.
The other way of crawling OSNs is using the APIs. For the top online social networks there are API interface available that can give the researchers the possibility to access the network through the API and gather the available information base on the policy of the social network. But base on the network the API has its own limitation in terms of scalability and performance.

Facebook Company provides a platform for their users that enable users to make their web site more social and well connected to the Facebook. The Graph API lets users to access the full social graph of a given user, allowing you to create a truly deep personal experience.

The Facebook API available at (http://developers.facebook.com/tools/explorer) is a platform for building applications that are available to the users of the Facebook. The API allows applications to use the social connections and profile information to make applications more involving, and to publish activities to the news feed and profile pages of Facebook, subject to individual users privacy settings. Also with the API, users can add social context to their applications by utilizing profile, friend, Page, group, photo, and event data. The API uses RESTful protocol and responses are localized and in XML format. Figure 25 shows the web interface of Facebook API.

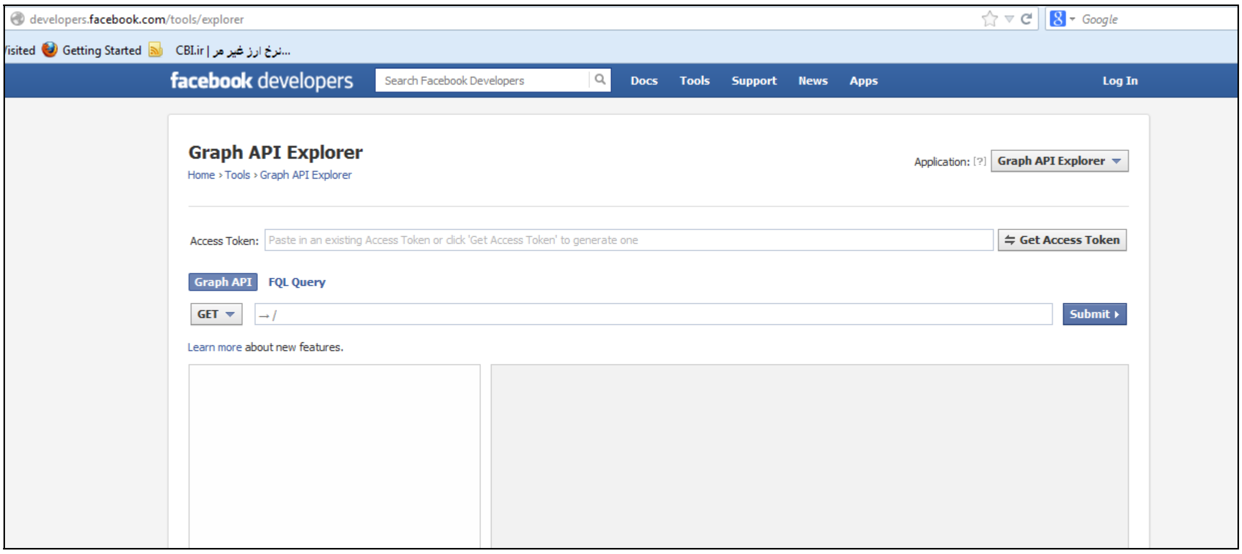

Figure 25: Web Interface of Facebook API

There are many features available in the Facebook API from developing for websites and application to getting information of pages and users. For the input of the API depending to the amount of information that you want to gather you need to provide the API access token. The other input is the ID or name of the objects in Facebook (Such as pages name, usernames or user IDs). For example in Figure 26 the response for the Paris name in the "GET" has been shows. As you can see in the reply you have many general information about the page such as number of likes and number of people that are talking about it.

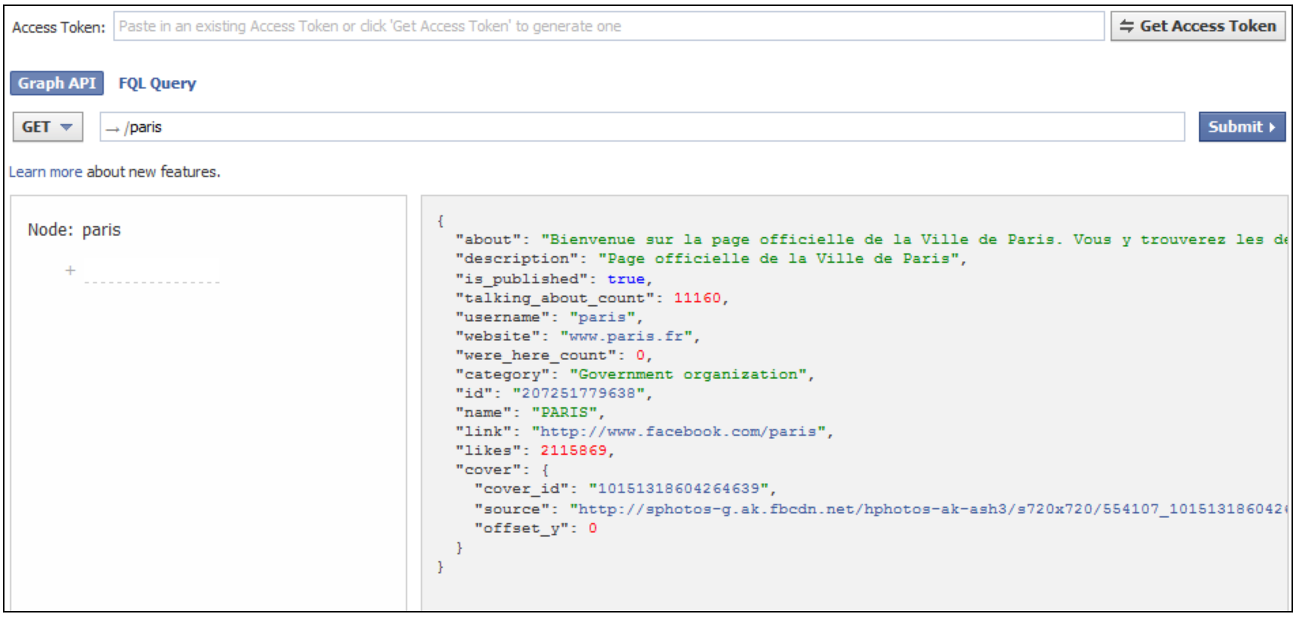

Figure 26: Web Interface response for term Paris in GET input.

The good point of this API is the possibility of use it through command line so with this option it is possible to make number of queries to the API to gather information. But this API similar to any other APIs has its limitation in terms of speed and scalability.

Apart from the using Facebook API for gathering the required information, there is possibility to collect the data directly from the html code of users and pages in Facebook. This method has many limitations. The first and main one is that by this method always you need to adapt your tool to the layout of the Facebook interface. As Facebook pages layout template is very dynamic and usually every few months Facebook is changing the format of the pages totally (such as change from the regular profile to Timeline layout few month ago), having a stable crawler by this method is not very feasible for long term.
Also for this method you should always has many active Facebook account to login and search in the profiles and pages. For a large scale crawler crawler needs a complementary tool to open Facebook accounts automatically and making this one is not a easy task to be done base on the many security check that Facebook recently add to this procedure.

3.3.3. Use of OSN Crawling in TWIRL

In twirl as the main goal is providing information for traveller such as recommendation for users regarding to tourism aspects, we can use the information available in the OSN mainly the travelling history of users. If we consider a travel from top view, we can consider two main module here, i) traveller, who that is going to do the trip. ii) The destination, the city or country or possibly the location that the traveller is considering to make the trip there.

For each of these two modules we can extract information from the OSN. For the first part that is the user part, we have access to profile of users in the social networks like the user profile in Facebook. The profile mainly contains several useful information about the personality and interest of the users. As a example the age, current location and job of a user in addition to the other attributes that is available in the profile of users can be used in the understanding the personality of the users. Also here in case of Facebook we have a list of interests that users join and LIKED them likes cities, countries and so on. Here also we have the possibility to find many useful information that help us to understand the taste of users in terms of travelling aspects.

Apart of the user part, we have the second module that is the destination part. For each city, or country or probably a location like museum or hotel, we will have a specific page in the Facebook that contains the initial description of the location in addition to the activity of the pages. It means for example if we consider a city as a destination here, we will have many posts in the wall page of the city in the Facebook including the type of the posts. So here probably for many of the destinations we will have many interesting information in terms of published posts including users reactions to each posts.

3.4 Data Mining

3.4.1. OSNs Data Mining

As popular OSN networks deals with hundred millions of profiles and pages and each of them has many information both static (personal information similar to name, age, birthday, etc .) and dynamic (posts, likes, comments, etc.) in their profiles in addition to the connectivity and friendships information, understanding this huge amount of data and retrieving useful information from the stored data, need advanced data analysis techniques. Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information here in this project will be information that can be used for traveller. Data analysis has multiple facets and approaches, encompassing diverse techniques under a variety of names, in different business, science, and social science domains. Data mining is a particular data analysis technique that focuses on modelling and knowledge discovery.

In this regard the first important point that should be considered is how we store this amount of data in a structured way in database. Here we use Mysql databases as it is very widely used in social network for example Facebook company store all users information in Mysql format and even they developed an Mysql API base named *FQL* for developer to connect and gather the information trough mysql queries as you can see in this link: (https://developers.facebook.com/docs/reference/fql/).

Later on from the stored information in Database, by using data mining techniques we will extract required and summarized information to use as a input of social information.

Generally saying Data mining involves six common classes of tasks:

1. Anomaly detection that identify unusual data records, that might be interesting or data errors that require further investigation.
2. Association rule learning: Searches for relationships between variables.
3. Clustering that is the task of discovering groups and structures in the data that are in some way or another "similar", without using known structures in the data.
4. Classification that is the task of generalizing known structure to apply to new data. For example, an e-mail program might attempt to classify an e-mail as "legitimate" or as "spam".
5. Regression that attempts to find a function which models the data with the least error.
6. Summarization by providing a more compact representation of the data set, including visualization and report generation.
7. Sequential pattern mining that finds sets of data items that occur together frequently in some sequences, which extracts frequent subsequences from a sequence database.

Here in this project as we are using social networks information that is a huge amount of data that need to be process, we mainly will use summarization, Association rule learning, Clustering and Classification.

3.4.2. Text Mining

3.4.2.1. About text mining

Since the birth of Natural Language Processing (NLP) in the sixties/seventies, automatic text understanding has been the subject of numerous researches, trying to catch the overall meaning of a textual document. Recurrent failures of developed systems pointed a too wide vision of this field. Indeed, these tools were not usable in operational contexts because of the high cost of all adaptations needed from one need to another (the knowledge bases and the lexical resources were too specific). Conscious of being too ambitious regarding the technological capabilities at this time, the researchers oriented their work towards more realistic text mining tasks. Realizing that it was not directly possible for a machine to understand a document as a human can do, a new and more reasonable goal was adopted to spot and extract a few pieces of information that best represent the overall document meaning [70].

Text mining is therefore a quite recent field that aims at automatically analysing natural language in order to extract relevant pieces of information. This generally leads to build a structured representation (databases, sheets, tables, etc.) of originally unstructured documents to ease the exploitation of large amounts of information. Having its target defined in advance, this task is leaded by the overall goal of the application it will be integrated to [70]. During last years, we have observed a growing interest for this research field and particularly through the creation of several evaluation campaigns such as MUC[13], ACE[14], CoNLL[15], TAC[16], ESTER[17], etc.

At the beginning, two main approaches emerged: symbolic methods versus statistical ones. Both are usually based on common pre-processing steps such as word segmentation («tokenisation»), lemmatisation (non-flexed form of words), morphological and syntactic analysis (sentence structure and relations between words). Linguistic approaches come from the Natural Language Processing (NLP) field and rely mainly on formal grammars manually coded by a linguistics expert. Annotations obtained from the pre-processing stages are used to build more complex rules and patterns defining all the possible contexts of occurrence for each type of entities, relations or events. It is worth noting here the importance of the syntactic analysis (syntagmatic or dependency) for the extraction of relations or events. The second kind of methods make use of statistical techniques to learn occurrence regularities from large textual corpus in which target entities have been previously annotated. These learning approaches can be supervised, unsupervised or semi-supervised and exploit either linguistic or non-linguistic features. Widely used methods are Hidden Markov Models (HMMs), Conditional Random Fields (CRFs), Support Vector Machines (SVMs), etc. [45]. Furthermore, recent researches tackle linguistic resources learning or semi-supervised learning combining annotated and raw data [43] to reduce the manual annotation effort.

Recently, a third type of approach emerged: text mining's actors explore hybrid techniques to overcome the limits of the latter methods and to enhance their performances. First of all, a major drawback of both linguistic and statistical approaches is that they tend to be domain-dependent or genre-dependent: their results' quality decreases when they are applied to different kind of texts, so there is a constant need to adapt the extraction models. Symbolic methods (based on hand-crafted rules) suffer from the cost of development and the need of linguistics' expertise to adapt the system. Statistical learning permits to cover a lot of occurrence contexts but require large annotated corpora to obtain good results and also leads to the construction of a "black box" model

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[13] Message Understanding Conference, http://www-nlpir.nist.gov/related_projects/muc/
[14] Automatic Content Extraction, http://www.itl.nist.gov/iad/mig/tests/ace/
15 Conference on Natural Language Learning, http://ifarm.nl/signll/conll/
[16] Text Analysis Conference, http://www.nist.gov/tac/
[17] Évaluation des Systèmes de Transcription Enrichie d'Émissions Radiophoniques, http://www.afcp-parole.org/camp_eval_systemes_transcription/

not easily accessible and so not customisable. To face these limitations, text mining experts propose to automatically learn linguistic patterns [17]. Statistical learning has also some drawbacks as it needs a large amount of annotated texts to build the extraction model. The task of corpus creation being also time-consuming, this kind of data is unequally available depending on the corpus domain and the type of annotations needed. In response to this, semi-supervised methods aim at using unlabeled data in the learning process [63].

The most common text mining tasks are named entities recognition [64], extraction of relations between these entities and events recognition. Named entities recognition is still a central task of text mining activities because named entities constitute necessary elements to understand the global meaning of a text and also basic information units that serve to extract more complex structures. Their definition is still under discussion in the NLP community but named entities are seen by a majority of experts as highly referential entities that refer directly to a real world's object (called «rigid designators» by [50]). These entities usually enclose proper names such as person, organisation and location names but also dates, percentages, measures, etc. Maynard & al. [58] propose the Muse system to handle named entity recognition on different domains and genres with little adaptation effort. The Avatar system developed at IBM Almaden research Center and based on the UIMA framework aims at combining rule-based annotators and probabilistic database techniques to improve the extraction's performances [48] [52].

Relation extraction aims, on one hand, at finding diverse links between these «simple» entities as, for example, relations between persons and organisations (employment, leading, etc.) and, on the other hand, at discovering entities' attributes like identity details for a person (age, address, job, etc.). Suchanek & al. [80] proposed to extend the pattern matching approach for information extraction by using deep linguistic structures instead of shallow text patterns. Snowball is another system for extracting relations from large collections of plain-text documents that requires minimal training and uses novel strategies for generating extraction patterns, as well as techniques for evaluating the quality of the patterns and tuples generated at each step of the extraction process [1]. Hasegawa & al. [41] proposed an unsupervised method for relation discovery from large corpora. The key idea was clustering of pairs of named entities according to the similarity of the context words intervening between the named entities. In the biomedical domain, Rosario and Hearst [74] compared five graphical models and a neural network for the tasks of semantic relation classification and role extraction from bioscience text.

Finally, event mining is particularly used for strategic or business intelligence activities [13] and can be seen as a kind of relation extraction where an "action" is linked to other entities like a date, a place, some participants, etc. Several MUC campaigns proposed event extraction-related tasks such as «template filling» and, as for text mining in general; two types of approaches are distinguished: symbolic ones and statistic ones. Aone & Ramos-Santacruz [4] developed REES, an event extractor based on linguistic rules manually constructed, coupled with a syntagmatic analysis. Along the same line, Grishman & al. [40] worked on epidemic events detection by using a finite-state transducer. On the side of statistical approaches, Ahn [2] proposes to combine multiple classifiers to extract events in the framework of the ACE campaign. Besides, pattern learning techniques or semi-supervised approaches appear also interesting as they try to get the better of the two "classical" currents [90].

3.4.2.2. Text mining on social media

3.4.2.2.1 Social media and social networks

The ubiquitous nature of Web-connected devices (desktops, laptops, tablets, mobile phones, etc.) enables users to participate and interact with each other in various Web communities such as photo and video sharing platforms, forums, newsgroups, blogs, micro-blogs, bookmarking services, location-based services, etc. Besides, new social networks provide platforms for communication, information sharing, and collaboration among friends, colleagues, business partners, and many other social relations. These «social media» become a niche of increasingly rich and massive heterogeneous data generated by the users, such as images, videos, audios, tweets, tags, categories, titles, geo-locations, comments, and viewer ratings. Social Media has emerged of late as a new form of individual expression and communication. Services like Facebook and Twitter allow users to write short messages to each other and to the world at large, talking about current events, politics, products, or whatever comes to mind.

3.4.2.2.2 Rights of use

Apart from confidentiality issues (that will not be discussed here), these new kinds of «public» communication involves property questions as a lot of content is shared and the demarcation between private and public information remains fuzzy at best. For many social media sites, the Terms of Service (TOS) are explicitly clear and to the point: If you post content to the site you essentially grant the site permission to use the content for any purpose they deem appropriate. In some cases, once you submit content it may instantaneously become the intellectual property of social networking site, even if you delete or purge the submission in its entirety.

Social media and social networks becoming more and more popular in humans' daily lives, the text mining community has an unprecedented opportunity to study novel theories and technologies for social media analysis and mining. Current challenges are accessing this data; discover potentially important pieces of information and transforming it into usable and actionable knowledge. Two main problems appear: first, social media data consists in huge quantities of electronic texts sitting in various applications so potential users are overwhelmed and need help to find relevant content; secondly, this data differs in some aspects from the data traditional text mining tools are built to process.

3.4.2.2.3 Big Data

As an example of this first problem, Wikipedia's article about social media says that «Twitter processed more than one billion tweets in December 2009 and averages almost 40 million tweets per day[18]». More recently, Twitter's CEO said that users of the micro-blogging service send out an average of one billion tweets every three days[19]. This new phenomenon, that is due to the whole Web expansion and not only concerns social media, is called «Big data». A first step to handle this «Big data» has been done by social media providers themselves by providing freely available API to allow a part of the data to be gathered and queried. Still taking the Twitter example, its API has enabled diverse applications to be created upon it. As the Twitter Streaming API delivers a large quantity of tweets in real time, Bifet & al. [8] proposed MOA-TweetReader, a new system to perform twitter stream mining in real time using an adaptive frequent item miner for data streams. Secondly, developments in «cloud computing» have made processing «Big data» easier by spreading the work broadly across networks of computers. Furthermore, a number of new visualisation techniques, such as word clouds or tag clouds, have been developed to help translating these vast quantities of text-mined words into something that is more compact and therefore more understandable [72].

3.4.2.2.4 Genre adaptation

Social media usually present some language particularities compared to other kinds of textual documents like press releases, professional reports and all formal human productions [24]. Indeed, as social media are produced by different people communities and in different contexts, this data appears to be very heterogeneous

[18] http://en.wikipedia.org/wiki/Social_media
[19] http://www.cbc.ca/news/technology/story/2012/02/13/technology-fbi-social-media-app.html

from a content point of view but also formally-speaking. Mining informally-written language poses unique challenges because tools have to handle spelling mistakes, improper punctuation, lack of capitalisation, poor grammar, etc. At a content level, social media data contain a lot of opinions, emotions, jokes, speculations, discourse incoherencies, unclear ideas being expressed in an unclear manner, etc. Ritter & al. [73] propose an unsupervised approach to discover dialogue acts (questions, statements, answers, etc.) in open domain texts. Indeed, as social media constitute free places to communicate in any forms and registers, it becomes very difficult to distinguish between different kinds of expressions. Ramage & al. [72] present a scalable implementation of a partially supervised learning model that maps the content of the Twitter feed into dimensions like substance, style, status, and social characteristics of posts. In top of that, data coming from social media are usually quite short messages, giving software poor or no context at all to understand the subtleties of meaning.

Social media therefore pose big challenges to existing text mining tools, trained or manually built towards formal texts like newswire articles. These «traditional» extractors are often structured in some sense: they deal with a narrow range of topics, or take natural language input that is written by professionals. Some researches have been conducted to investigate the performance of NLP tools trained on edited text when applied to unedited Web 2.0 text. For example, Foster [34] evaluated the Berkeley parser on text from an on-line discussion forum and presented some preliminary experimental results using simple transformations to both the input sentence and the parser's training material. Besides, some works proposed the use of «extra-message» context to ease the recognition of relevant entities [53] present an unsupervised NER system for targeted Twitter stream, called TwiNER that does not depend on unreliable local linguistics features and aggregates information garnered from the World Wide Web to build robust local context and global context for tweets.

We could also use any information provided by the user's profile or distance metrics in ontologies to disambiguate named entities.

3.4.2.2.5 Authenticity & trustworthiness

Dealing with community-produced content, authenticity also becomes an issue. Indeed, as in social platforms and social networks every user can express whatever he/she wants, informative messages are usually mixed with opinions, feelings, etc. Then, it appears very hard for mining tools first to know what is informative and what is subjective in any kind of message, and secondly to estimate the reality/quality/authenticity of the information reported. This really matters in intelligence gathering because erroneous information could lead analysts to take biased decisions. With social media expansion we have seen also the appearance of either «bots» or humans diverting social media usage by creating artificial user accounts or messages (as spam for emails) for various purposes: advertisement, propaganda, etc. This is not a new problem in the Web sphere but the wide-spreading of social media has amplified it and text mining tools (as IT technologies) have to be able to estimate the trustworthiness of social media data. Chen & al. [20] propose a semi-supervised Twitter scam detector based on a small labelled data. This system combines self-learning and clustering analysis. Some researches have also focused on detecting lies and deceptions among social media data: for example, Almela & al. [3] have developed a framework based on a SVM classifier to separate truthful and deceptive texts in Spanish.

3.4.2.2.6 Applications

A such large and rich multi-modality data is of high interest for various applications and especially for all types of open sources intelligence. Indeed, social media involve many interesting studies for both academic and business actors: how social media is produced, cited and used? How information propagates, being searched and found? How social communities evolve? What people talk or argue about some subject? What opinion people have about something? More generally, as such data embed human interactions and interests; their analysis is valuable for detecting trends, events and phenomena on today's Web reality.

For *business intelligence*, social media mining can:

- help organisations to understand the needs and behaviour of their customers without asking them to answer some questions or to complete a questionnaire [18],
- decrease the need of big marketing budgets or large focus groups,
- be integrated with other sources of customer data like static "focus groups" and paper-based surveys,
- give companies a better understanding of the general market and of their own and their competitors' customers.

In the *security domain*, apply text mining technologies to social media can help:

- predicting events from future terrorist attacks to foreign uprisings (weak signals detection),
- identifying emerging threats and upheavals,
- analysing live communications about crisis [36],
- tracking events over time, space and communities, such as the Arab Spring.

The latter are current major applications but social media mining has also possible integrations in health care community helping to diagnose diseases, in the music industry to find the future most famous artist among social media buzz, in the political domain to understand what are the main stances expressed in social media [79], etc.

3.4.2.3. Opinion mining on social media

Textual information in the world can be broadly categorized into two main types: facts and opinions. Facts are objective expressions about entities, events and their properties. Opinions are usually subjective expressions that describe people's sentiments, appraisals or feelings toward entities, events and their properties. A little amount of opinionated texts was available before the recent World Wide Web expansion.

Traditionally, text mining on social media data has been used to perform sentiment analysis. Indeed, sentiment analysis using text mining can be very powerful and is a well-established, stand-alone predictive analytic technique [89].

Opinion mining (or sentiment analysis and other related activities) is the problem of identifying subjective expression of author's opinion, attitude, mood or sentiment in texts. Although this is an established research topic in the behavioural sciences (see e.g. [46]) and actively explored in interaction design, it is a recent arrival in the information access field. A first international symposium on Theories and Applications of Exploring Attitude and Affect in Text was held at Stanford University in March 2004, sponsored by the American Association for Artificial Intelligence and organized by Clairvoyance, a text and information analysis corporation. Since then, a large number of research projects, industrial projects, and start-up companies have worked on identifying consumer attitudes [47], security issues, and financial news analysis (e.g. [10] [11] [37] [76] [77] [94]). There have been impressive engineering results in these first few years of practical sentiment analysis. The field at large has made great advances thanks to mature methodology and technology which has been available for straight-forward deployment in practical application: for text, most experiments use technologies originally designed for topical analysis, such as keyword occurrence tabulation. A good overview of the state of the art can be found in ([66] [82] [56]).

The opinion mining can be performed at several levels. In [66] and [84] a document-level opinion mining is investigated. The assumption here is that under several circumstances, e. g., in the area of customer reviews, the document under investigation only expresses one overall opinion. It is clear that this approach has its limitations as soon as comparative opinions occur. As many documents are a collection of both, objective and subjective statements, a classification on a sentence-level [88] is suitable for some tasks. The aspect-based opinion mining, relating opinions to entities like products or features of products, aspects of services or to named entities like persons, organisations or places is the most ambitious approach. It was introduced as feature-based opinion mining by Hu & Liu [44]. For the extraction of entities and aspects, different approaches using the frequency of nouns and noun phrases were tried in the past, examples are described in [44] [51].

The standard approach for an automatic extraction of opinions typically includes the following steps, after the text material has been appropriately pre-processed:

1. Topic and facet recognition: identification of named entities like persons, products, services events or other topic or facet thereof on which the author is expressing an opinion.
2. Subjectivity detection: identification of terms which indicate subjective attitude, sentiments, opinions or emotions expressed by the author of the given text.
3. Polarity measurement: evaluation of the polarity of the opinion uttered. This can be done on a simple binary (positive/negative) or on a continuous scale (e.g. with opinion values between –1 and 1).
4. Summarization: aggregation of the opinions. This includes the depiction in several dimensions like source, region or author. Also the display of the chronological sequence may be of interest.

As is obvious from the above step-by-step description, this process is resource intensive, requiring knowledge resources both for general language processing and for the various subtasks such as lexical resources for sentiment identification [32] [86].

Opinion mining is an actual challenge in a wide range of applications as opinions expressed can have an influence to decisions in many areas. For example, purchase decisions of consumers are triggered or at least influenced by opinions of other customers uttered in on-line reviews. Thus, companies producing goods or offering services, e.g., hotels, insurances or other service companies are keen on monitoring customers' opinions about their products or services. Therefore, opinion mining modules are widely implemented in social media monitoring tools (such as TweetFeel[20] or TweetSentiments[21] for the micro-blogging platform Twitter). Beside the above mentioned fields, the opinion mining has gained interest in the domain of political utterances during the recent years. Publications cover several topics like predicting election results with the help of Twitter sentiments [83] or predicting comment volumes in political blogs [91].

There is a recent growing awareness in the research community that sentiment is not only a question of polarity (positive/neutral/negative) but a many-faceted notion even on the local level [5]. Furthermore, each domain may have its own most appropriate representation of opinion and sentiment – in some cases modeled as a multidimensional space [59] or in some as a discrete palette of emotion [31] – and that the attempt to reduce all to a general case will hurt performance and usefulness. Several research efforts focus on transferring models found reliable in one topical domain to another [9]. The fact that attitudes and opinions are cross–linguistic communicative categories is well understood in the opinion mining field and even several benchmarks are cross–lingual. Tromp [81] investigated automated sentiment analysis on multilingual data from different social media including Twitter. He studied a four-step approach solving this problem, comprising language identification, part of speech tagging, subjectivity detection and polarity detection.

3.4.2.4. Some companies and tools

Nathan Gilliatt[22] (the principal of Social Target[23]) has identified about 200 vendors that have arisen from new media alone, and that their products are "all over the map." While it can be difficult to compare many of the vendors and many products overlap, he says a distinction lies between those that monitor and merge social

[20] See http://www.tweetfeel.com
[21] See http://www.tweetsentiments.com
[22] http://nathangilliatt.com/
[23] Social Target is a research and consulting firm that helps companies establish social media and customer intelligence and analytics capabilities, http://www.socialtarget.com

media with CRM[24] information, and those that provide more complex text analysis and wider system integration. We list below some of these companies and the tools they propose:

- Sysomos http://www.sysomos.com
  - Media Analysis Platform (MAP)
  - Facebook Page Central
- Lexalytics http://www.lexalytics.com
  - Salience Engine
- Inbenta http://www.inbenta.com
- Attensity http://www.attensity.com
  - Attensity Analyze
- Social Mention (Jon Cianciullo) http://socialmention.com
- Solutions-2 http://www.solutions2.be
- Viralheat https://www.viralheat.com
- Crimson Hexagon http://www.crimsonhexagon.com
  - ForSight Platform
- Texifter http://texifter.com
  - DiscoverText
- Luminoso http://www.lumino.so
  - Luminoso Platform
- Converseon http://converseon.com
  - Conversation Miner
- Soshio http://www.getsoshio.com
- Twendz http://twendz.waggeneredstrom.com
- Linguamatics http://www.linguamatics.com
- KNIME www.knime.com

Opinion mining

- Inbenta http://www.inbenta.com
  - Inbenta Sentiment Detection (ISD)
- CELI France http://www.celi-france.com
  - CELI France Opinion Monitoring
- Lingway http://www.lingway.com
  - Lingway e-Reputation
- SAS http://www.sas.com
  - SAS Sentiment Analysis
- Nstein http://www.nstein.com

[24] Customer Relationship Management

  - Nstein Text Mining Engine (TME)
- OpenText http://www.opentext.com
- Sentiment Metrics http://www.sentimentmetrics.com
- Clarabridge www.clarabridge.com
- RavenPack http://ravenpack.com
- Synthesio http://synthesio.com
  - Synthesio E-reputation
- AMI http://www.amisw.com
  - AMI Pack Opinion Tracker
- Viralheat https://www.viralheat.com
  - ViralHeat Social Sentiment
- OpinionFinder http://code.google.com/p/opinionfinder
- Appinions http://appinions.com
- Topsy http://topsy.com
  - Topsy Sentiment Analysis
- Crimson Hexagon http://www.crimsonhexagon.com
  - ForSight Platform

3.5 Conclusions

Data gathering and doing analysis on the raw and processed data is a main part of this project. As explained before in this section, several tools are going to be used in this regards to cover as much as available resources to provide requirements to further work packages of this project.

To this end, we are collecting data from different web resources from web crawlers to social network information and users' reaction and feedback by using different crawling techniques. To have a useful and summarized data for the project use cases and other tasks of this project, the methodologies for the data mining and analyzing the collected data also has been explained.

4 IMAGE RECOGNITION

Advancements in mobile phones equipped with digital cameras and provided high speed internet connections results frequent generation of huge amount of digital images. Existing technology embeds limited human understandable information into these files (e.g. Exif, GeoTagging). This information usually covers technical data generated by device sensors and parts. However content inside the image is not described by these sensors. Main aim of image recognition is to simulate the abilities of human vision by computer vision techniques (e.g. Image processing, clustering and classification). Image recognition allows computers to understand the content of an image by means of computer vision algorithms. It generates human readable, thus searchable information as well with vision sensors.

A vision sensor is specialized for specific target content like buildings, human face, cars, planes or any category from the real life. Similar to image sensors, these systems may also generate noise (e.g. partially or fully incorrect information). Objects in 3D world, has different appearances according to the perspective and position of the observer. Other factors like illumination, light source, resolution and occlusions also affect overall performance of vision sensors. For this reason a robust and efficient image recognition system must be able to handle objects (face and places) under different settings.

4.1 Introduction

Over the last quarter century, there is increased body of research on automatic identification of known objects. There are unlimited numbers of objects exist in real world. Therefore the first step to develop a vision sensor is to define the type of the objects of interest. Faces and places are the most common two objects in user generated images. In the scope of TWIRL project we mainly target face and place recognition in user generated photos.

In computer vision domain, face and place recognition systems aims to recognize and identify a person or a place in a digital image source. We present the major approaches to person identification and place recognition from the perspective of various fields in computer science as well as existing commercial products.
Face and place recognition is a complex process that may require specialized environments and hardware components (e.g. Infrared cameras, 3D and high-resolution cameras) to obtain better results. However in the scope of TWIRL project, we limit the hardware components to mobile phones and digital cameras.

4.2 Current Research Solution

4.2.1. Face Recognition

We start with the concept of identification in order to clarify how to approach face recognition problem. Person identification from cameras is a non-intrusive task to recognize a known human face. Identification defined as mapping a known quantity to an unknown entity as to make it known. It is a part of biometric researches and mostly occurs as a form of identification of person and access control for authentication. It could offer benefits in an almost limitless range of applications mainly in human computer interaction and security domain.

Although the research in face recognition systems started in 1960s, automatic person identification systems first developed by [Kanade 1973 96] at Kyoto University. Since then, the performance has improved significantly. Earlier studies considering the geometrical features of the face (e.g. distance in between facial features, angles) are not sufficient to discriminate different faces. Figure 27 presents general architecture of a person identification system.

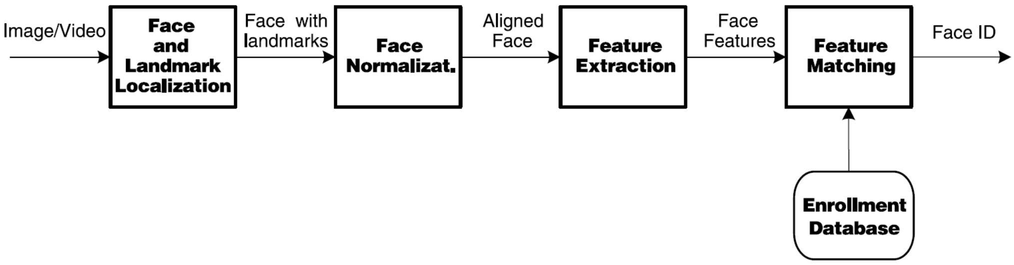


Figure 27: Generalized person identification process flow diagram [Stan and Jain, 2005,119]

Fig. 27 Face detection step segments the face from the background image and further processed to estimate facial landmarks (e.g eye, eyebrow, mouth, noise). Majority of the face detection applications use Viola-Jones Face detector [Viola and Jones, 2004,97] available in OpenCV library. Active Shape Models (ASM) [Milborrow and Nicolls, 2008,98] is a common method to localize facial landmarks.
Face normalization step normalizes the face according to the detected landmarks by using cropping, warping or morphing techniques. In order to reduce the lighting effects on the normalized face, image processing techniques used (e.g. histogram equalization).
Feature extraction step generates useful and informative data from the normalized face in order to increase intra-class variation while preserving inter-class variations. Invariant feature extraction is a common point among different methodologies. The most successful approaches for feature extraction are:

- Eigenfaces [Turk and Pentland, 1991,99]
- Local Feature Analysis (LFA) [Penev and Atick, 1996,100]
- Gabor wavelets [Wiskott et al., 1997,101]
- Local Binary Patterns (LBP) [Ahonen et all., 2004,102]
- Scale-Invariant Feature Transform (SIFT) [Lowe, 1999,103]
- Tensorfaces [Vasilescu and Terzopoulos, 2003,104]

Quality of the extracted features has significant effect on the matching results. Reducing the dimensionality of the extracted information is another important step towards better features.
The next step performs matching operation considering the enrolment database. The matching operation can be 1:1 (verification) or 1: N (identification). Feature matching is handled by computer vision, pattern recognition or artificial intelligence algorithms. Neural networks, Support vector machines, K-nearest neighbour and Bayesian classifiers are common classifiers used in matching process.

4.2.2. Place Recognition

There are increasing numbers of mobile applications available based location. Using 2D photo to locate user's location is a challenging problem due to the fact that the query and the ground truth data have different scale, rotation, lighting, view, seasonal and daily changes (day, night), occlusions and quality. Place recognition is the ability to recognize the place where the photo is taken. It is a largely unsolved problem in real world domain having unconstrained settings. The main goal is to identify familiar locations at different times and views satisfying robust results. Majority of the current research studies to eliminate these variations to obtain better results.

Place recognition can be combined with other techniques to extract high level semantic information from user photos. For example, one may find out user similarity in terms of photo interests by looking at the place of the photo taken by different users.
Place recognition (indoor or outdoor) in computer vision is part of object recognition and scene recognition. Majority of the research in place recognition performed considering mobile robotics where an autonomous mobile robot localizes itself to know its position in the world. Place recognition requires rotation and scale invariant feature extraction and matching methods as well as texture and contextual analysis. The problem can be solved either by global [Torralba et al. 2003, 108, Pronobis et al., 2006,109] or local [Ni et al, 2009,110] feature extraction methods.

An appearance-based approach, Bag-of-words (BoW) [Sivic and Zisserman, 2003 106] model is known to be the baseline approach for place recognition. Derivations of BoW approach is commonly used by other researchers for place recognition [Wu et al, 2009, 111, [Filliat, 2008], 111, Schindler et al. 2007,114]. In this approach, features of the image are represented by visual words quantized by the ground truth vocabulary or codebook.

In order to find a good representation of images, a feature extraction step is need. Algorithms in the extraction step usually selected from orientation and scale invariant methods. A list of common descriptor extraction algorithms are as follows;

- SIFT [Lowe, 1999, 103]
- SURF [Bay et al. 2006,115]
- ORB [Rublee et al. 2011], 120)
- FAST [Rosten and Drummond, 2006, 121]
- BRISK [Leutenegger et al. 2011,122]
- Binary Robust Independent Elementary Features (BRIEF) [Calonder et al. 2010, 116], which gives superior performance than SIFT and SURF in terms of both recognition performance and speed.
- FREAK [Alahi et al. 2012, 123]

BoWs suffer from perceptual aliasing where different places sharing the same features can be classified as the same place. In order to retrieve top most similar results, frequencies of the visual words with respect to the image and whole dataset (tf-idf) are computed using simple cosine function. Ranked list of results are further analysed to find the unique label of the image. Since tf-idf values represent the importance of specific features of the places, non-informative objects (e.g. trees, sky, person, vehicles) and informative but close up objects in the image may slightly affect overall performance of the model. Therefore segmenting non-informative objects from the foreground has positive effect on the query result. Note that background-foreground segmentation may also remove part of informative objects.

Another recent method is Histogram of Oriented Uniform Patterns (HOUP) [Fazl-Ersi and Tsotsos, 2012,105] which provides strong discriminative power for place recognition, while offering a significant level of generalization for place categorization. HOUP descriptors work on different subparts of the image and apply set of oriented band pass filters.

Other methods incuding SVM [Vapnik 1998], Bayesian filtering and Markov Chains [Dubois et al. 2011, 107] are also used for visual place recognition.

4.2.3. Major Challenges

Under the controlled and constrained environments, current state of the art in face recognition can surpass human recognition performance. In this scope, person identification can be thought as a well-solved problem.

However, varying illumination conditions are the most important problem for the traditional video based solutions. External factors dramatically affect the overall performance of existing approaches. A successful person identification system should be able to identify persons under challenging conditions.

Major challenges in person identification are:

- Uncontrolled lighting and illumination conditions
- Non-cooperative users
- Different viewpoint and head pose
- Facial expressions
- Occlusions (e.g. hair, accessories)
- Motion blur
- Makeup
- Ageing
- Low resolution cameras
- High dimensionality

Similarly major challenges in place recognition are:

- Ambiguity
- Uncontrolled lighting and illumination conditions
    - Seasonal and daily changes
        - Winter, Summer, Spring
        - Day-time vs. Night-time
- Different viewpoint
- Occlusions (e.g. tree, person, vehicles)
- High dimensionality

The COsy Localization Database [Ullah et al. 2008, 113] is a standard database to evaluate visual place recognition systems, which includes images having different illumination conditions. Similarly, New College Dataset [Smith et al. 2009] is a scene and image dataset having GPS and odometry information.

4.3 Funded Research Projects relevant to TWIRL

ITEA-CANTATA project provides content-aware multimedia processing systems by developing robust algorithms and common platform for content analysis and presentation. It provides content presentation that adapts to the device, user and content.

4.4 Commercial Solutions

4.4.1. Commercial Face Recognition Systems

Having the similar target concept, the Kooaba (Spin-off company from Swiss Federal Institute of Technology ETH) is a commercial cloud-based image recognition software for mobile devices. It unlocks the information captured in images using image recognition technology. Figure 28 presents supported objects in Kooaba project and Figure 29 presents the API of the project.

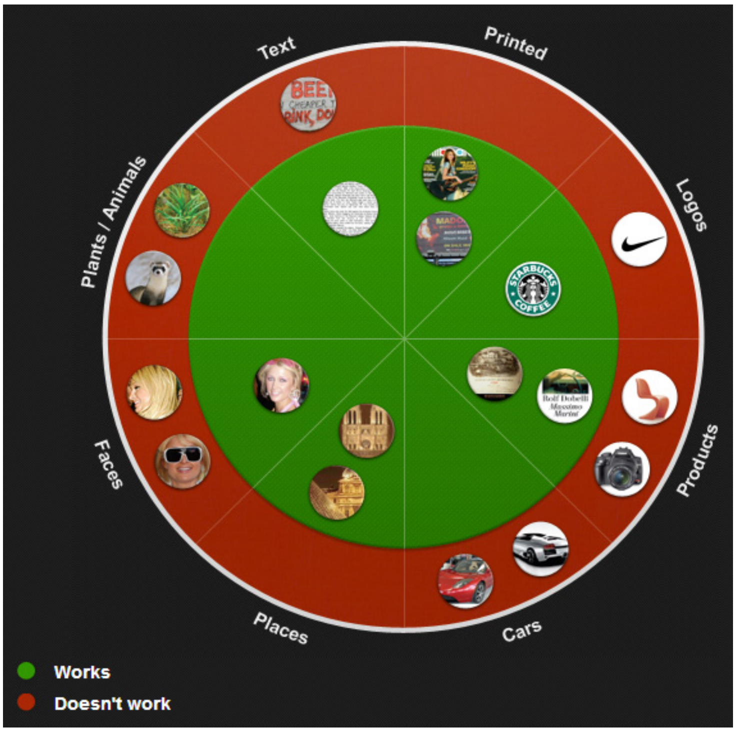


Figure 28: Kooaba object support

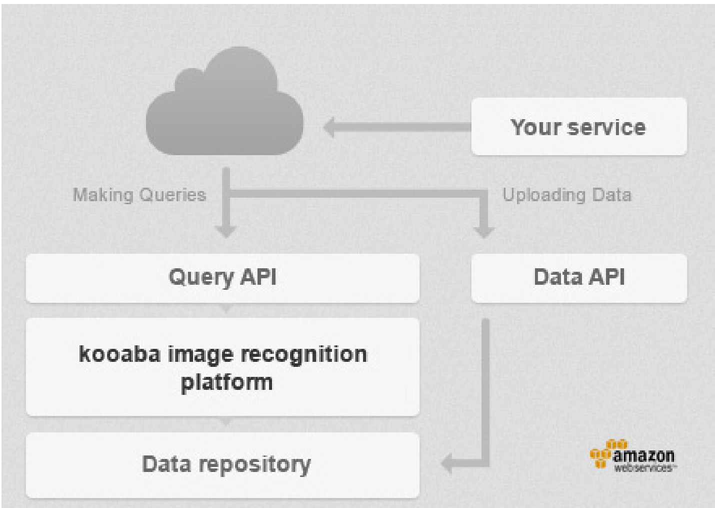


Figure 29: Kooaba API using amazon webservices

There are various APIs that provide client server based architecture like;

- Facebook PhotoTag Suggest
- Google+ Find My face
- faceFirst

FaceFirst has mobile Apps for BlackBerry, iPhone, Android, and Windows mobile platforms. Using a Java based client-server architecture the FaceFirst API runs identifications against large-scale watch lists, delivering match probability, face images and database records to mobile devices in a quick transaction.
Other APIs allows embedded face recognition in mobile platforms. Examples are;

- Verilook Embedded SDK
- Tessera Fotonation
- faceLock (Android)
- Visidon AppLock
- MORRIS

Verilook Embedded SDK provides a biometric API that works under Android environment. TESSERA FOTONATION (available in COACH and ARM platforms) which performs automatic identification of specific human faces in camera equipped mobile devices.
MORIS system analyzes 235 unique features in each iris and uses an algorithm to match that person with their identity if they are in the database. For the facial recognition, an officer takes a photo of a person at a distance of about 2 feet to 5 feet. Based on technologies from Animetrics Inc., the system analyzes about 130 distinguishing points on the face, such as the distance between a person's eye and nose. It then scans the database for likely matches.

4.4.2. Commercial Object Recognition Systems

Google Goggles (developed by Google Labs) available for both Android and for iPhone is the most popular application of image search engines.

Figure 30: Google goggles

Superfish.com provides visual search as a web service where an image is sent and relevant products similar to the input image returns.

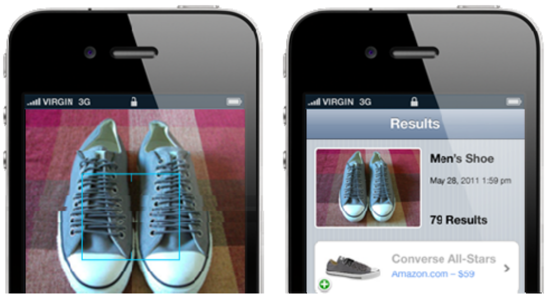


Figure 31: Object recognition from superfish.com

4.5 How TWIRL will advance SoA in this field

Twirl will deliver an open and extensible platform for combining cutting-edge technologies in image recognition, data integration, storage and querying. Complementary and interoperable technologies will be developed and integrated into extendable integration platform to maximize the technological exploitation. Developed technology will provide scalable semantically-enriched augmented reality as well as high precision and reliability.

4.6 Conclusions

Image recognition is one of the key features in Twirl that provides vision sensors to generate information related to the specific objects (e.g. face, places). Development of vision sensors for a specific target object will allow better use of extracted information by the end user applications. It bridges the gap between the low level image representations and high-level concepts by state of the art face detection and recognition algorithms.

5 VISUALIZATION AND INTERACTION TECHNIQUES FOR MOBILE DEVICES

5.1 Introduction

Not just conventional computers, mobile devices do not only allow users to perform a variety of tasks (such as accessing to Internet or other sources of digital information, etc.) but these tasks can also be performed in various situations 96. As a matter of fact, after the reduction in mass and size comparing to desktop computers, mobile devices have great advantages for those who are outside of home or office and they have been widely used by people in their travel issues or just when they are moving.

When using mobile devices, users are not always focusing on the screen and may be paying more attention to another activity. For instance, a traveller could write an email with his cell phone when visiting a place. Moreover, the specific form factor of handheld devices complicates their use as they only provide a small screen and limited input tools (stylus, no physical keyboard). The lack of screen space makes it difficult to display large amounts of data and entering text by using a virtual keyboard is obviously harder than when hitting keys on a PC keyboard. Mobility conditions can also degrade the interaction: text will be harder to read if the user is moving, items will be more difficult to select in public transportation, etc. Handheld devices thus differ from conventional computers not only because they must be handled differently but also because they are used in a mobile context that affects the way of interacting.

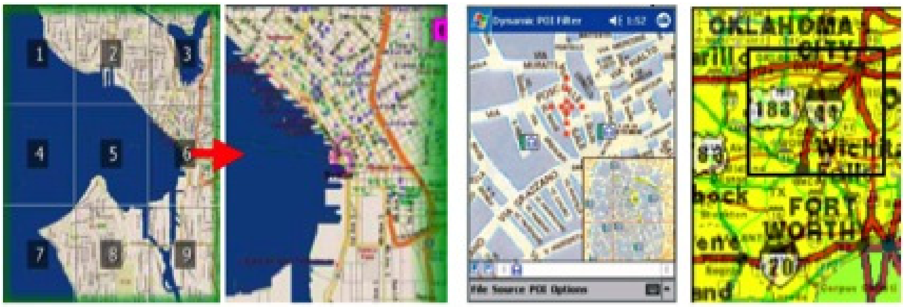
Nowadays, many techniques related to information visualization and augmentation as well as user interaction have been proposed to overcome the limitations of mobiles devices. Actually, during the development of information visualization techniques the designer has to take into account the users' tasks or context to choose the graphical metaphor as well as the interactive methods to be provided. This means that the above techniques are so related that they can be considered as a whole when designing and implementing a friendly user interface for mobile devices. Thus, a global state of the art for the techniques of user interface design of mobile devices is very necessary for the purpose of getting a clear vision of present technical situation and helping the design of new interaction techniques.

However, currently, the reviews of existing interface techniques of mobile devices were mostly carried out in focusing on some specific aspects. For example, 125 presented a state of the art on the data input methods for mobile devices, while 126 presented a state of the art of the different techniques of presentation on PDA (Personal Digital Assistants) screens that have been developed in response to the lack of space on these screens. Besides, 127 described a space for classifying the existing input and output interaction techniques that have been proposed for mobile devices, and 128 focused on current mobile augmented reality applications.

Since that project TWIRL (Twinning virtual World on-line Information with Real world off-Line data sources) aims to create an open platform able to process, query, enrich, interlink and fuse data originating from real world applications and knowledge extracted from virtual data sources so as to make the applications of mobile devices richer, more personalized and more social, here, in terms of the user interface on mobile devices, we provide a state of the art of interaction techniques including three categories: information visualization, user interaction and augmented reality for helping us to conceive, develop and evaluate novel user interface for mobile devices.

5.2 Information visualization

Information visualization is meant to support the analysis and comprehension of (often large) dataset through intended techniques to show/enhance features, patterns, clusters and trends, which are not always visible 129. With a mobile device, the biggest limitation of viewing large quantities of information would be its small screen. For improving this situation, various visualization techniques have been presented and they can be classified by a general multiplexing metaphor (which means sending multiple streams of information on a carrier at the same time in the form of a single signal) that was initially proposed for visualization 130-131. Three types of multiplexing can be distinguished: time, space and depth multiplexing, which are illustrated below by an example where the user wants to see a map at different zooming levels:



a) b) c)

Figure 32: Visual multiplexing: a) time; b) space; c) depth.

- *Time multiplexing* means that different parts of the information are shown at different moments at the same place. What is being presented at any moment can be controlled either by the system or directly by users. In Figure 32a, a view that corresponds to a new zooming level is shown in place of the initial view.
- *Space multiplexing* means that different parts of the information are shown simultaneously on the same spatial area. It either involves brushing and linking (such as in overviews with detailed views) or Focus+Context techniques (such as fish eye representations). Figure 32b shows a detailed view with an overview on the right bottom side.
- *Depth multiplexing* means that different parts of the information are superimposed on the same area. In Figure 32c, a transparent global view is superimposed on the detailed view.

Besides, some functions related to physical characteristics and aimed at the improvement of information presentation on small screen should also been paid attention to. In the following, we illustrate each multiplexing strategy and related physical functions with examples.

5.2.1. Time multiplexing

Numerous visualization techniques are based on time multiplexing. Zoomable interface (ZUIs) 132 that used a zooming metaphor to let users navigate an information space follow this principle and this idea has been applied to mobile devices. In ZoneZoom 133 (Figure 32a), a map is divided into nine portions and each portion is associated with a physical key. By pressing one key, the user zooms in the corresponding portion of the map. Treemaps 134 can also be seen as a kind of a ZUI. For example, in 135 (Figure 33), the discussion threads of a forum are displayed in a Treemap. The user visualizes information about threads by moving the stylus across the rectangle corresponding to the Treemap node, and can see its content by clicking on it. In this case, the user controls the scale of a map to visualize a variable level of detail. A filtering process can also be used as a way to control the representation. In 136, the user navigates in a large data set by using the Fathumb, a navigable tree of hierarchically organized facets, which contains metadata attributes of the data set.

Figure 33: Treemaps. Left: visualization of the threads in two discussion forums. Right: the articles of a thread are nested inside one another.

Besides, 137 presented a novel interface for mobile map navigation based on Semi-Automatic Zooming (SAZ). SAZ gives the user the ability to manually control the zoom level of an SDAZ (Speed-Dependent Automatic Zooming) interface, while retaining the automatic zooming characteristics of that interface at times when the user is not explicitly controlling the zoom level. Concerning the photo browsing, a compact photo browser for smartphone 138 has been proposed to place numerous photos effectively by overlapping identical photos. This system helps people place more than 200 photos automatically in a single phone screen with a user-friendly browsing interface that enables us to set the viewing detail and overview configuration simultaneously. Figure 34 shows its user interface. Actually, the design of photos browser has considered not only the temporal multiplexing strategy but also the spatial multiplexing strategy, which will be described in the next section.

Figure 34: Left: the overview shows all of the auto-generated albums like a table of contents. The photo collage is used for explaining each cluster and an algorithm that scatters photos and occludes one another is used. Right: the detail view shows auto-generated albums on top pane and selected album's photos on bottom pane.

5.2.2. Space multiplexing

The visualization techniques based on space multiplexing can be introduced in several items, which are the concept of *Focus+Context*, the *visualization of off-screen objects*, and the *visualization of 3D models*.

Focus+Context techniques make it possible to display a global view (context) simultaneously with a detailed part (focus) of information space. Elements that have a high degree of interest at a given time are displayed with a size that is large enough to make them more readable. Such techniques provide effective solutions to compensate the lack of screen real estate on small displays and they are generally based on Fish Eye 139-140 representations that perform an "optical" or logical deformation of the visual space.

In 141, a new technique for displaying list on small screens, called SpiraList, was presented based on the space strategy that follows Focus+Context paradigm. Items are displayed in alphabetical order on the spiral layout in such a way that the first visible item and the last one are contiguous in the list (Figure 35). The focus area is located on the bottom of the outermost revolution so that the labels are fully visible on a handheld screen in portrait mode (in landscape mode, the focus appears at the right of the spiral). The SpiraList provides an efficient solution for displaying data at arbitrary locations in a global view, but it is most suited for lists that do not exceed 100 items. Thus, for the purpose of obtaining better performance of larger lists (e.g. 500 items), the SnailList was then proposed based on the combination of space and temporal multiplexing. With SnailList, the context zone appears first in the innermost part of the spiral and is always shown at the same location (Figure 36). The user must select one letter to make the focus to appear. Finally, full details will appear in the focus area, at the top of the spiral as shown in Figure 36c.

Figure 35: SpiraList: (a) a screenshot and (b) a picture of SpiraList in action

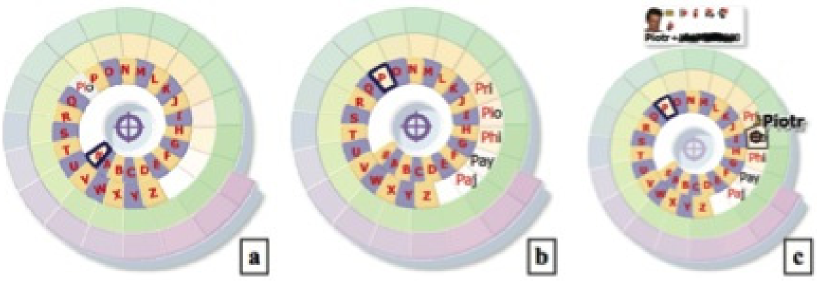


Figure 36: SnailList: (a) context, (b) intermediate view and (c) focus

Another example expecting both space and temporal multiplexing could be the DateLens 142 in which a calendar is displayed (Figure 37). The selected day is magnified at the center of the screen and other days appear at a smaller size to increase the available size on the screen.

Figure 37: Interface of DateLens

Technologies for *visualization of off-screen objects* can be seen as space multiplexing strategies as they provide information about target located outside of the focus zone. They are also time multiplexing strategies in that sense that users need to pan the map to see the actual targets. As a matter of fact, Overview+Detail and Contextual Cues Techniques are two approaches that have been explored most in the literature to mitigate the off-screen objects problem.

Overview+Detail provides both detail and context information by typically displaying two separate views simultaneously, one for the context and one for the detail 143. With regard to Contextual Cues Techniques, Halo 144 represents surrounding off-screen objects of a map by drawing rings that are large enough to reach into the border region of the display window. Nevertheless, according to 145, Halo conveys direction and distance, but it susceptible to clutter resulting from overlapping halos. Thus 145 presented Wedge (Figure 38), a visualization technique that conveys direction and distance, yet avoids overlap and clutter. Wedge represents each off-screen location using an acute isosceles triangle: the tip coincides with the off-screen locations, and two corners are located on screen. Besides, the approach HaloDot 146 (Figure 39) has also been proposed for enriching the Halo off-screen visualization technique. It aims to improve direction awareness of off-screen objects, to give hints about their relevance, and to prevent cluttering when there are a large number of off-screen objects. Actually, a comparison between Overview+Detail and Wedge has been implemented by 147, and the results show that Overview+Detail allows users to be faster in searching for off-screen objects and more accurate in estimating their location.

Figure 38: (a) The problem: Halo arcs point users to off-screen targets, but overlapping arcs are hard to interpret. (b) Wedges point to the same off-screen locations; since they avoid over-lap, the display remains intelligible

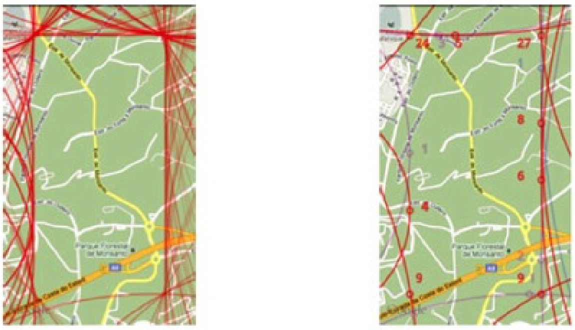


Figure 39: Halo (left) and HaloDot with aggregation and number clues (right)

Researches concerning *3D visualization* on mobile devices are also studied in recent years. For instance, 148 introduced a new approach for visualization of 3D city models on mobile devices without installing any specific application or plugin and 149 presented a system architecture for service-oriented, interactive 3D visualization of massive 3D city models on thin clients such as mobile phones and tablets. As interactive visualization of large 3D architectural models on mobile devices would significantly benefit applications such as indoor navigators and mobile tourist guides, and currently, few PDAs are equipped with 3D hardware accelerators, 150 proposed and experimented a system that exploits hierarchical view frustum culling and portal culling for interactively visualizing 3D architectural models on mobile devices. Related to the multi-dimensional data visualization techniques, 151 has presented MINI (Mobile Image Navigate Interface), which is a novel 3D visualization system for retrieval results adopted to run on mobile platforms such as smart phones. The MINI allows users to interactively browse multi-dimensional datasets based on priority of data items calculated from multiple user criteria. It achieves the display of retrieved data items in the 3D space while avoiding overlaps and preserving adequate representation of the items' priorities. It also supports interactive orientation and provides a zooming user interface. Figure 9 shows the interface of MINI.

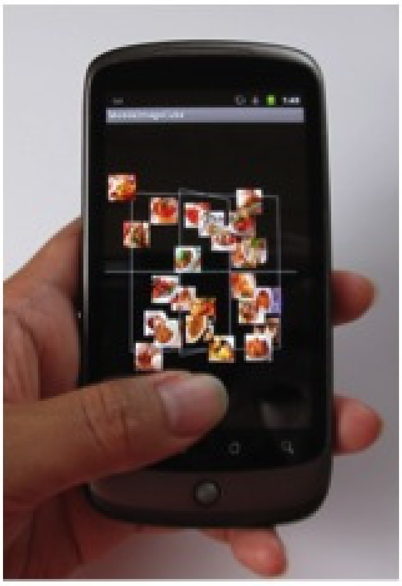


Figure 40: 3D image browser MINI. The user is rotating the 3D space

5.2.3. Depth multiplexing

One of the early systems using depth multiplexing is Macroscope 152 (Figure 32c) where two superimposed views of the same map are displayed, each of them with a different zoom factor. See-Through tools 153 such as Toolglasses are another example. These transparent widgets make it possible to apply a command to an object placed beneath. This principle has been applied to mobile devices to design new interaction techniques. In the technique presented in 154, the mobile device acts as a Toolglass by letting the user move it over a map to retrieve information. In addition, *Augmented Visualization* was introduced in 155. It is an interaction method for projection walls as well as monitors using affordable and widely available hardware such as mobile phones or tablets. Figure 41 shows illustrations of the idea. The term augmented refers to Augmented Reality (AR), a technique that overlays virtual objects and information on the real world to enhance human visual perception. AR will be discussed precisely later in this document.

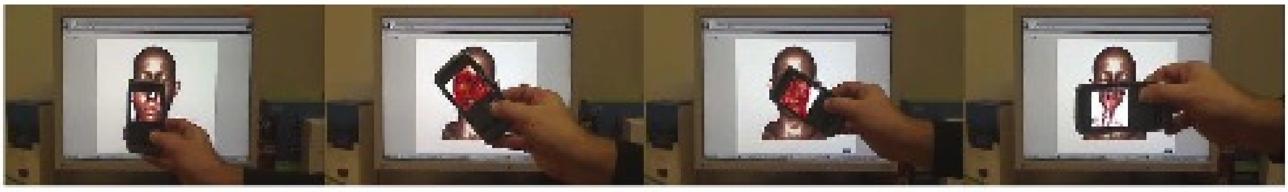


Figure 41: The magic lens metaphor in augmented visualization

Other modalities concerning data representations

Till now, most techniques introduced deal with the visual modality. This is not surprising as, according to 156, 70% of the perceived information comes from the visual channel. Nevertheless, the audio and haptic modalities should not be neglected. For example, Speech Skimmer 157 allows a user to control the auditory presentation through a simple interaction mechanism that changes the granularity, time scale, and style of presentation of the recording. Using the EarPod 158, the user can select music without seeing the information. Audio feedback is provided when the user moves his finger among the items of a circular menu. Sound localization is also used in where loudness varies to help the user to navigate in a music database.

Although haptic sense can hardly represent a large set of information as its lower resolution than hearing or sight, the notion of tactile zooming has been experimented in 159: the screen is divided in 16 regions, each of them corresponding to a dot of a Braille actuator. The objects, that are made perceptible through the activation of the dots, can be “displayed” at several zoom levels. In 160, a haptic device is placed on a handheld to allow eyes free navigation. Various signal patterns are sent by the haptic device according to the nature of the information displayed on the screen.

In fact, there are also some physical characteristics functions of mobile devices aiming to minimize congestion and improve the presentation of information on the limited screen. First of all, as we know, with mobile devices, it is possible to choose the orientation of the screen: vertical or horizontal according to the requirement of task or our personal preferences. Besides, with the increase of the battery power, we can also vary the brightness of screen (e.g. blinking, highlight the display), or activate a motor that vibrates the mobile devices to warn or inform user.

5.3 User interaction

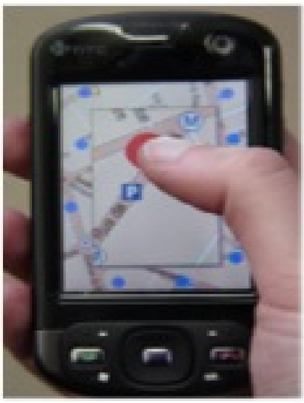
When interacting with mobile devices, two factors are most important: the physical devices that user interact with and the interaction languages. Mobile devices allow users to interact with various physical devices such as tactile screens, keyboards, hardware buttons, microphones and various sensors. Correspondingly, interaction languages can also be many categories, for instance, movement interactions, voice interactions and passive interactions.

5.3.1. Movement interactions

According to different physical devices, the techniques of movement interaction can be different. When concentrating on the tactile screens, movement interaction languages can be classified based on the format of the values given by the user: ***pointing*** interaction and ***gesture*** interaction.

A "***pointing***" task typically occurs when selecting a target or choosing an item in a menu. Multiple selections are a subcase when several contiguous pointing tasks are performed (as, for example, multiple item selection in a list). As mentioned before, there are several problems involved with target selection on small tactile screens, such as accuracy, border accessibility and occlusion. Thus, several techniques have been proposed to solve these issues and they can be grouped into three categories: *tapping, dragging* and *hybrid techniques*.

- *Tapping* techniques capture the position of the pointer when the finger touches the screen. The most widely used technique on regular or small touch-screens, Direct Touch, relies on this intuitive principle. The user must tap the screen precisely at the location where the target is displayed. This technique is fast but it is also very error prone for selecting small targets because the location of the contact point is hard to anticipate. Hence, the TapTap input technique 161 (Figure 42 left) has been proposed as a solution to improve Direct Touch. TapTap is based on a straightforward idea: if a single tap does not make it possible to select a small target accurately, a second tap should suffice to disambiguate the selection. More precisely, the first tap defines an area of interest on the screen; this area is then magnified and displayed as a popup on the center of the screen; the second tap selects the desired target in the popup (or cancels the selection if an empty space is selected). Starburst 162 (Figure 42 right) is another technique that aims at improving Direct Touch: it identifies areas of the available screen space, grows a line from each target into the available space, and then expands this line into a clickable surface.



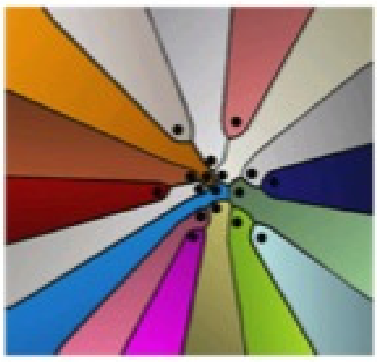


Figure 42: TapTap (left) and Starburst (right)

- In LauchTile 163, users interact with a large circular button so as to navigate among the applications. Besides, the ForceTap 164 was introduced as an interaction technique that increases the touch screen input vocabulary by distinguishing a strong tap (ForceTap) from a gentle tap (Tap) by utilizing accelerometer data available on many mobile devices. When a user taps on a touch screen, the device momentarily moves to the direction of the force that the finger applies to the screen. This movement can be measured by monitoring the acceleration of the device along the direction perpendicular to the touch screen. As shown in Figure 43.

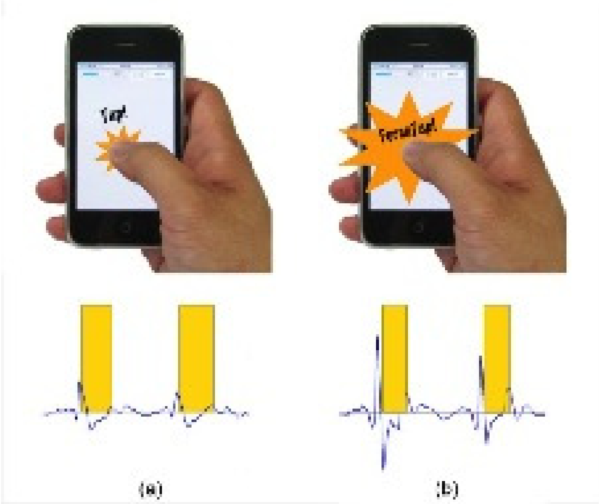


Figure 43: Z-axis accelerations (curves) and touch event (bars) caused by (a) Taps and (b)

- *Dragging* techniques consist in pressing the screen, dragging a cursor, and lifting the finger to validate the selection. A cursor is displayed at a fixed distance above the contact point to help the user to reach the topmost locations of the screen. The first technique based on this principle, Offset Cursor 165, was designed to solve the accuracy problem of Direct Touch. This technique and its variants make use of a variable gain between the finger and the cursor. For instance, in 166 an adaptative gain is added to cursor movements: the offset is null at the center of the screen and grows smoothly towards the left and right borders to make it easier to reach the screen borders. Offset Cursor techniques have been shown to produce much less errors 165 than Direct Touch but they are significantly slower (because users tend to systematically overshoots or undershoots the cursor 167). In order to increase the efficiency when many targets are present on the screen or if they are close to each other, the MagStick 161 was proposed. MagStick is based on Semantic pointing, and the cursor is attracted at the center of a target when entering a proximity area. The user moves the cursor by controlling a telescopic stick whose movements are symmetrically opposed to the thumb. Semantic pointing improves selection accuracy and occlusion is unlikely as the thumb moves away from the target. In addition, an interaction technique named Bezel Swipe 168 was presented for mobile devices with touch screen to support multiple-selection, cut, copy, paste and other operations without interfering with zooming, panning, tapping and other pre-defined gesture (Figure 44).

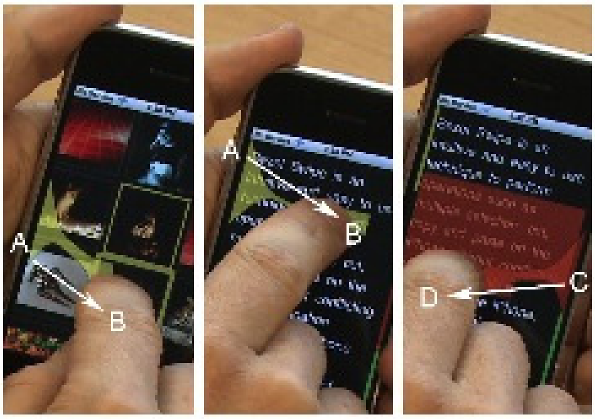


Figure 44: The Bezel Swipe prototype in action. Left panel: A swipe from A to B selects an image. Middle panel: A swipe from A to B marks the beginning of a text selection. Right panel: A swipe from C to D marks the end of the text selection.

- *Hybrid techniques* mean the combination of tapping and dragging techniques. Shift 169 attempts to decrease the selection time needed by Offset Cursor by proposing a hybrid approach that combines Direct Touch and a on demand precise adjustment step. Touching the screen triggers a callout that shows a copy of the occluded area in a non-occluded area. The actual selection point (under the finger) is represented by a cursor in the callout, and the user adjusts its position to fine tune selection before releasing his finger. This strategy improves selection time as the callout is only used for fine-tuning small target selections. However, Shift does not completely solve the screen coverage problem, as it requires users to put their fingers close to the target location. In Escape 170, the user presses his thumb close to the target, and then makes a linear gesture according to the direction shown by the icon of the target he wants to select. Nevertheless, this technique does not solve the problem of selecting targets close to the borders and makes it difficult to use gestures or dragging operations for other functions as they are already used to disambiguate targets. Similar techniques have also been applied in photo displaying on mobile devices. Due to the convenience of taking pictures with various digital cameras and mobile devices, people often end up with multiple shots of the same scene with only slight variations. To enhance photo triaging, in 171, an effective and easy-to-use brush-and-drag interface had been proposed. This interface allows the user to interactively explore and compare photos within a broader scene context. This novel interaction method was implemented on a consumer-level tablet computer and demonstrated to offer effective interactions in a user study (Figure 45).

Figure 45: The brush-and-drag interface. (a) A given group of similar photos. (b) We use a natural brush gesture with our finger(s) to mark an area/object of interest in one of these photos. Our tailored segmentation engine quickly segments the corresponding image elements in the photo group. (c) We can then drag the segmented image elements to spread them out for better examination. This user-centric design allows the user to decide the size and the area of interest. It also maintains the overall photo context while enabling the user to focus on the selected area of interest for comparison and photo triaging (focus+context). Note that the normally black background of the tablet display was changed to white for printing purposes.

The most important difference between ***pointing*** interaction and ***gesture*** interaction should be that the gestures languages can be scale independent and they allow eyes free selection once the user had learned gestures. Here, we will introduce the current *gesture* interaction techniques for mobile devices in the following three categories: *touch-screen gestures*, *on-device gestures* and *contact-free gestures*.

- *Touch-screen gestures* are used in techniques such as EdgeWrite 172 which allows to enter text by drawing "symbolic letters" with a stylus inside a small squared box. Directional gestures are used in AppLens 163 to navigate in a set of applications. In 173 a prototype digital drafting table, Manual Deskterity, was presented and it supports both pen and touch input so as to support novel compound gestures. As the input vocabulary for touch-screen interaction on handhelds is dramatically limited, especially when the thumb must be used, the MicroRolls 174 (thumb gestures) have been presented to expand touch-screen input vocabulary by distinguishing rolls vs. slides of the thumb. In order to interact with small user interface components, Gesture Avatar 175 (Figure 46) was proposed and it allows users to operate existing arbitrary user interfaces using gestures. Besides, 176 has presented the two-finger gesture hold-and-move as an alternative to the disruptive long-tap which utilizes dwell times for

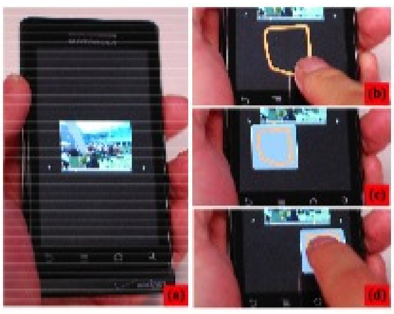


Figure 46: (a) Small mobile interface widgets are difficult to operate through fingers. (b) In Gesture Avatar, the user can draw the shape of the target, e.g., the rectangle for the knob of the slider. (c) Gesture Avatar finds the widget that best matches the user gesture and shows an avatar attached to it. (d) The user can then operate the widget (e.g., the slider knob) through the avatar, e.g., by dragging the avatar to move the video slider.

switching from panning to object dragging mode in touch interfaces. For the purpose of facilitating the transition from novice to expert usage, some hybrid techniques have been proposed and they are based on the idea that the user will learn gestures progressively by performing the same gestures in novice and expert modes. A visual representation that guides the user is displayed in the first case but not in the latter case. For instance, QuickWriting 177 let users choose a letter in a menu by performing a gesture from the center of the menu to the letter. Users learn gestures by practicing and are eventually able to select letters eyes free. Marking menus 178 and their variants such as Flow menus 179, Control menus 180, Wavelet menu 181, and Leaf menus 182 are based on a similar principle. When using these techniques, the menu only appears if the user presses the mouse for a fraction of a second without moving it. Another advantage is that they are faster than linear menus as selection only depends on the direction of the gesture and there is no need to point at a precise location as with linear menus. Another research area about touch-screen gestures should be the bezel-based gestures. Recently, researchers 183184 have explored using the bezel of the phone for eyes-free interaction. Bezel refers to the physical touch-insensitive frame surrounding a touch screen display (black-colored area in Figure 47). Bezel menus are built on the periphery of the touch screen (activation area in Figure 16a) without occluding the screen space 168. The initiation of a bezel gesture starts from outside of the screen (Figure 47b), solving the mode-switching problem. 183 showed that for bezel gestures users performed better in the eyes-free mode than when looking at the phone and 184 indicated that bezel menus solves the occlusion and mode-switching problem and ameliorates the fat-finger problem. Marks do not have to be very precise. Bezel menus can work under direct sunlight, when it is difficult to access the on-screen controls. They can make the display icon-free, resulting in more screen space for the actual content.

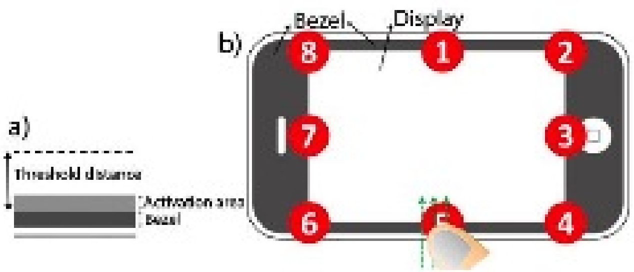


Figure 47: (a) Activation area (grey) and threshold distance, (b) Eight level-1 menu items, numbered 1 to 8 at bezel (black), and the start position of the finger to select item-5

- *On-device gestures* are usually proposed to overcome the limitation of mobile devices, such as the small screen sizes, the limited input methods and the drawbacks of one-handed interaction. Actually, these gestures should be designed with respect to ergonomics and hand anatomy as well as human-side aspects. 185 has evaluated gestures regarding the ergonomic aspects while interacting with mobile devices and present ergonomic requirements of finger gestures on the back and side of a vertically as well as horizontally hand-held phone, such as dragging and lifting fingers from the surface. The results suggest that drag and lift gestures have the potential to be executed one-handed while using the phone and that certain device configurations may be accessed seamlessly with that type of gesture control. TimeTilt 186 gesture is based on a lenticular metaphor and aims at both reducing the activation time when switching between views, and supporting a natural mapping between the gestures and the

Figure 48: TimeTit helps to “travel in time” to reach previously opened windows. A tap on the back of the device triggers a continuous mode so that the user can navigate through windows by performing smooth gestures. A discrete mode can be activated with jerk movements.

navigation (Figure 48). JerkTilts 187, quick back-and-forth gestures that combine device pitch and roll, may serve as gestural self-delimited shortcuts for activating commands. They only depend on device acceleration and rely on a parallel and independent input channel and do not interfere with finger activity on the touch screen. In addition, DoubleFlip 188 has also been presented as a unique motion gesture designed as an input delimiter for mobile motion-based interaction and it is distinct from regular motion of a mobile device. Combining the motion gestures and touch-screen gestures, in 189, an experimental prototype was presented. It enables surface gestures through both the back and front sides of a tablet and can sense multiple, simultaneous finger movements. The device also detects changes in orientation, allowing users to express commands using motion. With regard to the hand-held tablets, most tablets use just one hand for interaction, to free the other for support. Hence, in 190, the BiTouch design space, which introduces a support function in the kinematic chain model for interacting with hand-held tablets and the BiPad, a tookit for creating bimanual tablet interaction with the thumb or the fingers of the supporting hand were presented and evaluated. It is worth to mention that recently, Canopy Sensus 191, which is a touch sensitive case for smart phone has been presented. It can be considered as an accessory for mobile applications. When touching the back or right side of Sensus, the touch sensors talk with the micro-processors in Sensus and transmit that information to the phone (Figure 18). Till now, it works only for Apple products.

Figure 49: Playing mobile game with Canopy Sensus

- *Contact-free gestures* mean the interactions with mobile devices with no touch (both screen and device). They are normally based on camera capture, sensors, and computer vision techniques which have advanced such that it is now possible to fairly accurately recognize people's body, arm and hand gestures. In 192, E-Gesture, an energy-efficient gesture recognition system using a hand-worn sensor device and a smartphone, has been designed, implemented and evaluated. E-Gesture employs a novel gesture recognition architecture carefully crafted by studying sporadic occurrence patterns of gestures in continuous sensor data streams and analyzing the energy consumption characteristics of both sensors and smartphones. As now users prefer using multiple mobile devices interchangeably by switching between the devices, in 193, a simple swiping gesture was proposed to realize the migration of applications between mobile devices at runtime. In addition, when the user is engaged with a real-word task it can be inappropriate or difficult to use a smartphone. To address this concern, ShoeSense was developed in 194. It is a wearable system consisting in part of a shoe-mounted depth sensor pointing upward at the wearer. ShoeSense recognizes relaxed and discreet as well as large and demonstrative hand gestures. Some other contact-free gestures can also be realized by the augmented reality techniques, which will be introduced precisely in this document.

5.3.2. Voice interactions

Voice interactions are especially useful for bind people but it can also serve the sighted people when they focus on other things and cannot directly watch the screen of mobile devices (e.g. EarPod 158). By reason of the small size of mobile devices, text entry poses difficult problems. As a solution, speech recognition provides an alternate way to enter text, such as the Siri 195 from IOS (Apple's mobile operating system). Siri lets users use their voice to send messages, schedule meetings, place phone calls, and so on. Vocera 196, a mobile hands-free voice communication system, was proposed to enhance communication in hospital work. Besides, specific sounds or a melody can also be recognized with the "Query by humming" 197 technique that makes it possible to find a piece of music in a database. However, speech recognition systems are unlikely to work properly in a noisy environment or if the user speaks too fast. Speech recognition is thus often limited to the recognition of keywords. For this, 198 proposed an efficient post-processing method for correcting the results obtained when users use voice recognition software on mobile devices.

5.3.3. Passive interactions

If the user interface could adapt automatically to the context of environment without explicit action from the user, this kind of interactions can be called passive interactions and their corresponding applications are named context-aware applications. Passive interactions are based on the use of sensors such as microphone, on-board sensors and also light sensors, temperature sensors, pressure sensors, etc. The information collected by these sensors like user information or social/physical environment information, can detect the changes in a new situation. For instance, in 199, the phone ring of the mobile device changes according to its position (in a hand, on a table, outside). A mobile device with a GPS can show to the user where he is currently located on a map. CAMB (context-aware mobile browser) 200 can change its characters in different context (e.g., when user walking, the mobile device is shaking, thus, the font size on the web page is increased and when in public that imply both noisy and silence requiring environment, muting all sound sources on the webpage such as background music or videos can then be a judicious decision). In addition, context-aware applications are also able to discover and make use of others resources that are available in the user context. In 201, an application superimposes touristic data on the images that are captured by the camera. The system is thus able to detect the context when tourists are approaching to an attraction. Similarly, a mobile device could discover that a large display screen is available in an office building and, thus, temporally use this screen to display information. Huddle 202 is a system that automatically detects appliances in the context (for example a television, a DVD player and a projector). Huddle then generates graphical interfaces that can control the multiple appliances.

5.4 Augmented reality

Although augmented reality (AR) research dates back to the early 1960s, the technology seems to have become to fruition only recently – nearly 50 years after its invention. Researchers have solved many technical challenges during that time, finally allowing practical access to this user interface. While early AR research focused on head-mounted displays and backpack computers, it now encompasses a variety of enabling technologies, including camera phones, Kinect (3D camera) and other handhelds, advanced projector-camera systems, and AR-extended professional devices, such as x-ray scanners. It is this evolution that has finally made it possible to use AR in our daily lives 203. Actually, according to Gartner, 821 million mobile devices were sold in 2012 and this number will rise to 1.2 billion units during 2013. Although not all these devices are open for custom software development, the trend toward open software environments for mobile devices seems inevitable.
Nowadays, various commercial applications have recently been emerging in the mobile consumer domain at an increasing pace – Layar, Junaio, Google Goggles, and Wikitude are perhaps the most prominent ones. In 204, current publicly available mobile AR applications were roughly classified into two common approaches: AR browsers and image recognition-based AR applications (Figure 50). Both types of applications rely on the visual modality of human senses in exploring the digital information related to real-world objects and places. In addition, previous related works on AR could also been divided into two areas 205: annotation authoring and approaches for tracking mobile devices in large-scale environments in real time. In terms of techniques, 206 introduced a software environment for AR on mobile phones, discussed development and debugging strategies, and showed how to execute several tasks of a common AR system in parallel on a mobile devices. And then 207 discussed how to overcome the most severe limitations, such as memory, rendering speed, and computational power.

Figure 50: Illustrations of AR interfaces. Left: AR browser with geo-bound content, Right: image recognition AR for acquiring product information through a barcode (visual marker)

Here, for the purpose of considering all the contributions of AR in mobile devices, we are going to introduce them in three categories: detecting real environment, entertainment augmented information, and gesture input. User experience of existing AR applications will also be discussed in the end.

5.4.1. Detecting real environment

Jim Spohrer 208 first envisioned the idea of superimposing georeferenced information using AR in his 1999 essay on the WorldBoard. This idea has recently gained popularity with applications such as Layar 209, which use camera phones equipped with a compass and GPS as an inexpensive, albeit crude, platform for AR. However, GPS sensors and compasses have limited accuracy ad can't provide precise pose information. To improve this situation, a novel system 205 had been presented which uses vision-based orientation tracking and enables accurate object registration tracking. It employs a nature-feature mapping and tracking approach for mobile phones that's efficient and robust enough to track with three degrees of freedom. By assuming pure rotational movements, the system creates a panoramic map from live video on the fly and simultaneously tracks from it (Figure 51). This system also let users create annotations at that moment and store them in a self-descriptive way on a server for later re-identification. In 208, AR technique has been used for aiding public participation in urban planning. A smart-phone prototype system was developed which showed 3D virtual representations of proposed architectural designs visualized on top of existing real-world architecture, with an appropriate interface to accommodate user actions and basic feedback. In addition to outdoor detecting researches, the positioning and orientation in indoor environments have also been studied in 211 (Figure 52). It proposed a system that processes a cell-phone camera image and matches detected landmarks from the image to a building. The system calculates camera location and dynamically overlays information directly on the cell phone image. With regard to direct control of physical devices in real world, PICOntrol, a new approach using an off-the-shelf handheld pico projector for direct control of physical devices through visible light had been presented in 212. The projected image serves a dual purpose by simultaneously presenting a visible interface to the user, and transmitting embedded control information to inexpensive sensor units integrated with the devices. To use PICOntrol, the user points the handheld projector at a target device, overlays a projected user interface on its sensor unit, and performs various GUI-style or gestural interactions. PICOntrol enables direct, visible and rich interactions with various physical devices without requiring central infrastructure (Figure 53).

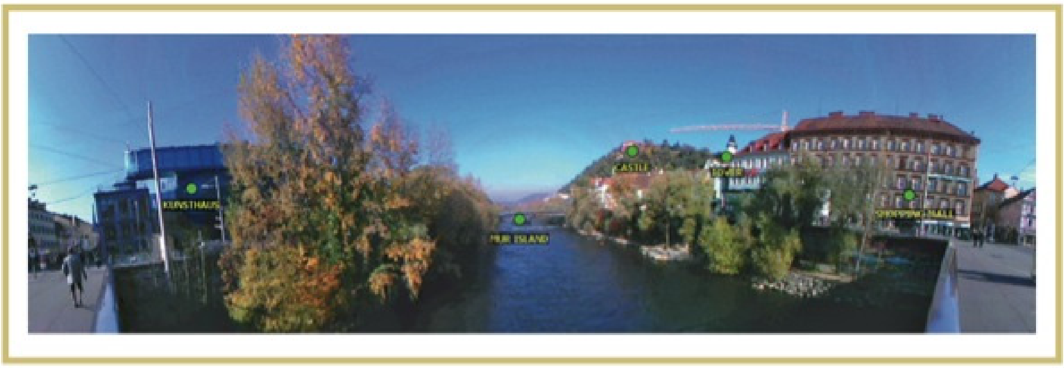


Figure 51: The vision-based system presents an improvement over regular compass-based annotation systems. By creating and storing panoramas, it can locate and visualize annotations with pixel accuracy

Figure 52: Information overlays on a camera-phone display image. The image shows both an overlaid navigation aid (the directional arrow) and a “magic lens” type window for displaying dynamic information about the current surroundings

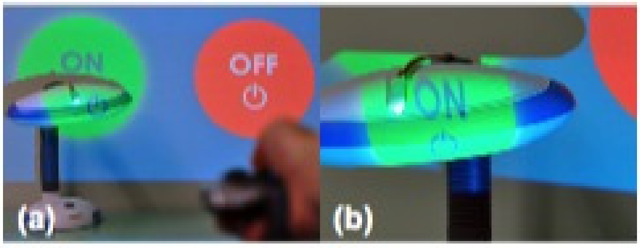


Figure 53: A simple example of PICOntrol interaction. (a) Pointing the handheld projector at a lamp. (b) Casting the projected button “ON” over the sensor unit and pressing an activation pushbutton on the projector turns on the lamp

5.4.2. Entertainment augmented information

AR technology enables a mobile phone to be more powerful to visualize the information no visible to naked eye and this function has been used a lot for entertainment. For instance, Layar can easily add the digital content to print media and it lets publishers infuse static pages with interactive experiences. Similarly, the use of AR for overlaying visual information on street posters has also been studied in 213 (Figure 54). It explored the design space of hybrid interfaces (AR component + zoomable view component) for augmented posters considering mobile users’ contexts and the characteristics of AR. With this user interface, users are not forced to keep the physical poster in view when watching the augmented information or video, the AR view could change to zoomable view by pointing the phone away from a poster. A game poster case study was also shown with the proposed hybrid interfaces collaborating with programmers, 3D artists and graphic designers. In the area of AR games, in 214, a client-server Chinese chess game on mobile phones was implemented by AR techniques. GeoBoids 215 (Figure 55) is also a mobile AR game that incorporates video see-through and spatialized audio AR techniques and encourages player movement in real world. In the game, the player is surrounded by flocks of virtual creatures that are visible and hearable through mobile AR application. The goal is for the player to run to the location of a GeoBoid swarm in the real world, capture all the creatures there, then run to the next swarm and repeat, before times runs out, encouraging the player to exercise during game play. Many other AR games can be found in 216.

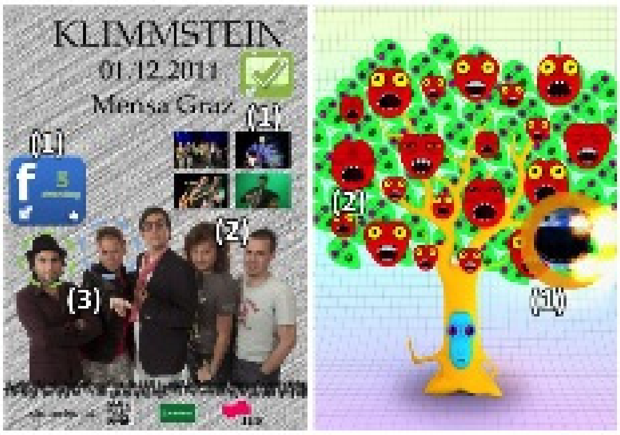
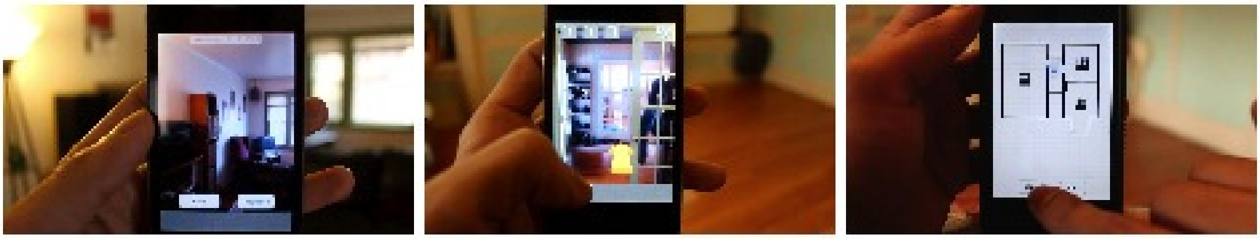


Figure 54: Posters with depicted digital content. Left: event poster with 2D media items like widgets (1), image collection (2), trigger regions for showing/hiding content (3) and videos (not visible). Right: game poster with 3D (1) and 2D (2) animations.

Figure 55: Demonstration of mobile AR game GeoBiods

Besides, AR applications are also used to do some design work. For example, 217 presented a novel smartphone application designed to easily capture, visualize and reconstruct homes, offices and other indoor scenes (Figure 56). The output of the system is two-fold; first, an interactive visual tour of the scene is generated in real time that allows the user to explore each room and transition between connected rooms. Second, with some basic interactive photogrammetric modeling the system generates a 2D floor plan and accompanying 3D model of the scene, under a Manhattan-world assumption 218. With regard to the advertising, the TineMelk 219 (Figure 57) AR application was presented to create interactive AR stories for the mobile platform. There is an AR marker was printed on the back of more than 50 million milk cartons. The app was part of a four month campaign to raise awareness of locally produced and distributed milk and was built on an existing marketing concept of cows talking like humans when unobserved. Using the Layar AR platform, 220 had developed a set of interactive science activity tools that smartphone users can use to explore phenomena via augmented exhibits at the museum Exploratorium and at locations in the San Francisco Bay Area.



(a) Capture data (b) Playback interactive tour (c) Generate indoor floor plan

Figure 56: The proposed system captures an interactive visual tour and a floor plan of an indoor scene, in real time, on a smartphone. (a): Capture data; (b): Playback interactive tour; (c): Generate indoor floor plan

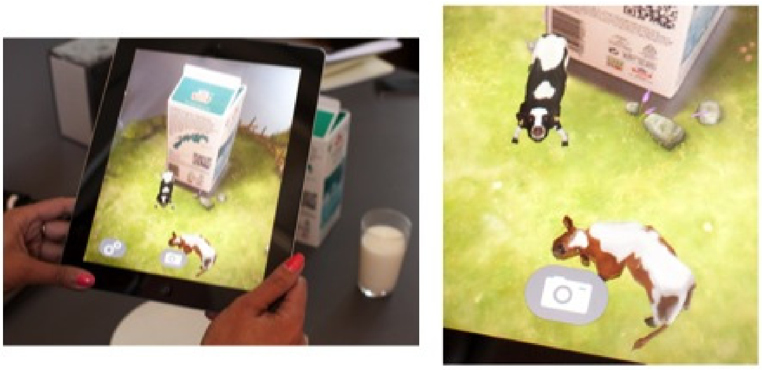


Figure 57: The TineMelk AR app on the iPad 2

5.4.3. Gesture input

Thanks to the techniques of hand tracking by camera, gesture input is now possible for AR interface on mobile devices. In 221, a one-handed approach for AR and interaction on mobile devices has been proposed. It considers common situations with mobile devices such as when a user's hand holds a mobile device while the other hand is free. In this approach, a virtual object is augmented on the palm, using a palm pose estimation method. The augmented virtual object reacts (e.g. moving or animation) to motions of the hand such as opening or closing the hand based on fingertip tracking (Figure 58). Moreover, it provides tactile interactions with the virtual object by wearing a tactile glove with vibration sensors. Being involved in AR researches for several years, HIT lab NZ (Human Interface Technology Laboratory New Zealand) has proposed some interaction methods based on freeze view touch and finger gesture for handheld AR interfaces 222. A similar method called "Freeze-Set-Go" has also been proposed in 223. This interaction method lets users to freeze the real worldview tentatively, and continue to manipulate virtual entities within the AR scene. According to the user experiment, the proposed method turns out to be helping users to interact with mobile AR environments using touch interface in a more accurate and comfortable way (Figure 59). Besides, several different techniques (gesture input captured by camera phone, tangible input, keypad interaction and so on) for 3D object translation and rotation in a mobile phone AR environment had been compared in 224. Usability experiments found that tangible input is best for translation tasks, while keypad input is best for rotation tasks. It also explored the use of the front camera in the phone to provide hand tracking input for virtual object translation and orientation.

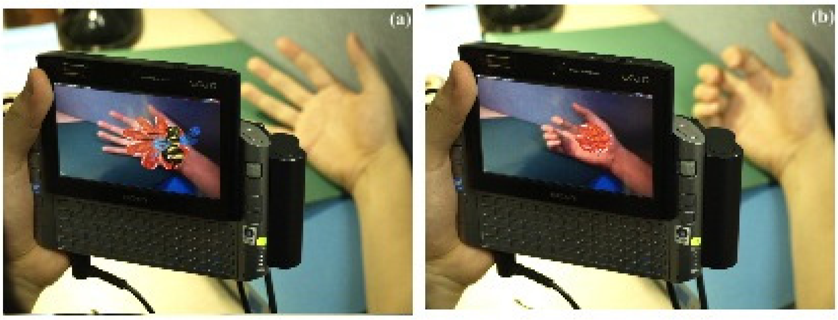


Figure 58: Interactions with a virtual object when (a) opening and (b) closing the hand

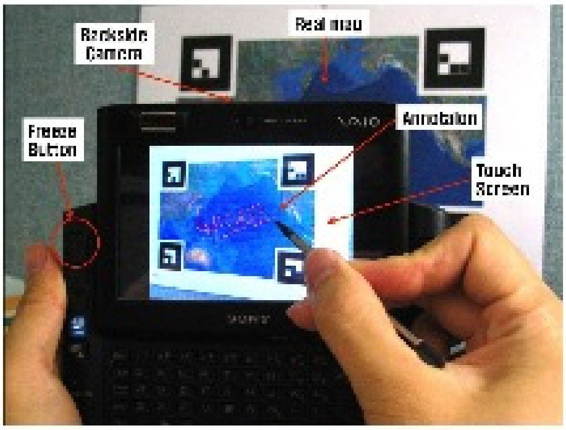


Figure 59: Prototype implementation: annotating on a real map

5.4.4. User experience of AR applications

Actually, an online survey to explore the user experience of early stage mobile AR applications available in the market in spring 2011 had been conducted in 204. This survey covered both location-based AR browsers and image recognition AR applications for object-based interaction and it identified various types of experiences such applications have evoked by qualitatively analyzing 84 users' narratives of their most satisfying and unsatisfying experiences.

In the results of this survey, most often the satisfying experiences showed pragmatic and instrumental aspects of efficiency in information acquisition, empowerment with novel and unequalled tools and ways of utilizing information, and awareness of the digital content related to one's immediate surroundings. Strong amazement, general excitement and surprise seem to have been the most frequent emotionally oriented satisfying experiences. The most unsatisfying experiences highlight mostly different grades of instrumental dissatisfaction: from frustration to disappointment and general dissatisfaction. The unsatisfied experiences are mainly results of inadequately performing technology (e.g. hardware deficiencies) or instrumental expectations not being met. As many of the applications are rather immature both regarding extent of functionalities and usability, the probable experiential challenges fall in the minority (e.g. issues related to relevance, reliability and liveliness of content, interacting with AR, or AR causing physical risks in the surroundings).

6 CONCLUSION

In this document, we have presented and classified existing techniques on mobile devices concerning information visualization and augmentation as well as user interaction. Three typical drawbacks of using mobile devices: small screen, limited input tools, and mobility condition have been carefully considered when designing these above technologies. In fact, each technique of visualization or interaction described before has both advantages and drawbacks as it was initially presented for solving some specific problems, such as TapTap technique for fat finger problem, etc. Thus, according to the requirements of project TWIRL and based on this state of the art, some new technologies of visualization and interaction on mobile devices should then be designed to make the TWIRL user interface being richer, more personalized and more social.

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