



Project Results

RoboNimbus

Smart robot management using AI and the cloud

The ITEA project RoboNimbus (Smart Platform for Robot Management and Coordination with AI-powered Cloud) developed a cloud-based, AI-powered robot management platform combining technologies to connect, monitor, control and maintain robot fleets.

Robots are becoming increasingly capable and affordable. This incentivises their use in more sophisticated processes, but multi-robot coordination requires smart management via a central platform. Within this, AI-based techniques are crucial to preventing efficiency from dropping as the number and variety of robots increase.

The vision of RoboNimbus was the development of an all-in-one robot management platform, allowing users to manage multiple robots via web and mobile applications. The project's use-cases focused on the healthcare domain, connecting two types of robots to collaborate on a task. The Turkish partners focused on an autonomous mobile robot (AMR) that can be directed to a patient's room for remote examination or equipment delivery and collect patient data to send to the management software. In Korea, work was done on a cobot arm that can pick up objects, such as urine samples, and place them in a requested area.

Technology applied

The platform's foundation is Kubernetes, an open-source container orchestration system with a structure in which services are automatically scaled and the resulting load is met even when the user load increases. This allows RoboNimbus to collect large volumes of field data, mostly in near real time. Kubernetes also provides a multi-tenancy structure through which multiple users can access their own portals and load their own robots and buildings,

providing RoboNimbus with a robust, scalable framework to host multiple web applications. Within the platform, a task assignment line enables the automation of task optimisation based on the capabilities, location and availability of robots, ensuring minimal cost and timely execution. For demonstration purposes, the cobot arm and the AMR collaborate in a simulation environment: the AMR collects samples from patients and transports them to a counter, where the cobot arm places them into containers or other mobile robots.

With the platform, users can send tasks to the web or mobile application, which sends them to the cloud for assignment. Various AI software innovations are hosted within the cloud platform to enable this. For the AMR, anomaly detection is based around mechanical vibrations, visual classification and joint detection via visual segmentation, while context-based navigation has been achieved with semantic environment labelling based on visual sensor data and navigation parameter selection using semantic labelling. A predictive maintenance system has also been built to constantly check the health status and report potential malfunctions in advance. For the cobot arm, inverse reinforcement learning (IRL) and trajectory learning enable the robot to adapt to new reaching and inserting motions. A virtual reality (VR) and mixed reality (MR) framework also enables, among other things, recognition of the user's hand gestures for position control, rotation and grip of a remote cobot using HoloLens

hand tracking. With this combination of the cloud platform and AI software, there is no need for database installation.

Making the difference

Through RoboNimbus, the consortium has set up a solid foundation for the further development of multi-robot coordination. The focal point is the platform, which currently allows ten users to define their own robots and



^ Robotic nurse.

assign tasks simultaneously (versus an initial aim of five users). Technical improvements on the state of the art have also been achieved. For the AMR, a success rate of 99.8% was reached in the test set for anomaly detection, while potential malfunctions can be notified up to 150 days in advance. For the cobot arm, testing of 200 different target positions took place in Gazebo-

ROS simulation and the success rate for reaching and inserting motions was 96%. These results were all achieved against an initial value of zero.

For the partners, the first steps are now being taken towards commercial exploitation, which is foreseen as both Software as a Service (SaaS) and Product as a Service (PaaS). For the former, customers would pay a subscription fee to use the platform via cloud services. For the latter, customers could use the platform as a white-label product in which the complete solution, including the software codes, is integrated with their products. To enable such exploitation, RoboNimbus has ensured alignment and compliance with the VDA 5050 standard so that all robots within this standard can be integrated into the system.

As most of the partners are SMEs, a major benefit of exploitation would be an increased share in the healthcare robot market, valued at USD 12.65 billion in 2023 and expected to reach USD 52.36 billion by 2032. The partners are also considering expanding their activities into the advertisement and logistical warehouse domains. In the shorter term, however, they have improved their individual knowledge and expertise and have developed important international connections through ITEA's collaboration framework. As a result, BYS Grup and KIRO are developing a follow-up project on the integration of surgical robots into the platform and will utilise upcoming ITEA events to explore potential partners. This will ensure that RoboNimbus' current innovations continue to develop while opening up new pathways for their exploitation.

Major project outcomes

Dissemination

- > Several presentations at conferences/fairs: e.g. Türkiye Artificial Intelligence Forum (TYZF24), The International Strategic Communication Summit 23, International Data Science and Statistics Congress IDSSC 2024

Exploitation (so far)

New products:

- > RoboNimbus Platform: AI-powered, cloud-based robot management platform.
- > CNN based image segmentation model: deep learning-based image processing solution.
- > Time series-based anomaly detection model: for fault detection in industrial processes.
- > Time series-based time-to-failure prediction model: for proactive maintenance systems.

New services:

- > SaaS Model: subscription-based platform access.
- > PaaS Model: integratable white label solution.
- > Cloud-based deep learning model delivery: image and time series based AI services.
- > Robot capability management system: for tasks such as navigation, precision docking.
- > Robot management with remote API integration: remote task management with autonomous systems.

New systems:

- > AMR Assisted Patient Data Collection: data collection from patient rooms via autonomous mobile robot.
- > Cobot Assisted Sample Handling: cobot handling system for picking and placing samples.
- > Scalable containers with Kubernetes: to meet increasing user load.
- > Multi-user management with multi-tenancy architecture.
- > Algorithms to convert map data to coordinate system.

Patents

- > 2 patent applications in preparation in Türkiye.

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Partners

Republic of Korea

- > GES Engineering
- > Korea Institute of Robotics & Technology Convergence (KIRO)

Türkiye

- > BYS Grup
- > POLONOM TEKNOLOJİ

Project start

January 2021

Project end

July 2024

Project leader

Ko Yong Ju, GES Engineering

Project email

oxmitggol@geseng.co.kr

Project website

<https://www.robonimbus.com/>
<https://itea4.org/project/robonimbus.html>



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