imec

An imec.icon research project | project results

ICT

SafeDroneWare

An architecture and platform for multiple drone applications, ensuring maximum safety and supporting autonomous behavior

The market for drones is expanding rapidly for consumers and businesses. Drones can be used in applications as diverse as industrial inspection, security, logistics, agriculture, and entertainment (such as pop concerts or drone shows). Unfortunately, uncontrolled use of drones can result in harm to people and property. Relying on manual control is not only very complex and prone to human error, it is often an inefficient way of providing a drone service.

"In the context of SafeDroneWare, the project consortium wanted to define an architecture and a corresponding platform for supporting autonomous drone behavior that complies with general as well as application-specific safety specifications", says Tom Holvoet, research lead of the SafeDroneWare project. "The project has taken an integrated approach to develop low-level and application-level software, drone sensors, hardware, and reliable wireless communication. We have also addressed legal concerns, allowing the drone to operate within EU and worldwide legal frameworks. With this re-usable and integrated framework, assistance and ease of use can be provided to the drone operator, while ensuring maximum safety to people and property." Two real-world use cases have been selected to demonstrate the developed technologies, i.e. electricity pylon inspection and air quality monitoring.

THE OUTCOMES

1. A methodology and architecture to enable a high-level description of the drone's expected behavior

As part of the SafeDroneWare project, a methodology has been developed that allows specifying the drone's behavior, compliant with the specifications of the mission. More particular, the methodology allows the description of safety constraints, on the basis of which a decision-making mechanism is being generated.

A typical example of a safety constraint for pylon inspection is the minimum distance of the drone to the pylon. When this distance is reached, a decision-making mechanism will ensure the drone to move away from the pylon. This mechanism is demonstrably correct, i.e., it can be shown that the drones behavior will be conformal to the safety constraints that are described within the specifications. In a next step, the proposed methodology has been translated into an architecture. This architecture serves as a model for the platform that manages the drone's operation.

Tom Holvoet: "For the first time, techniques such as constrained based programming and automated planning have been used to specify a drone's behavior. On top of that, we have developed a modular solution, allowing to easily upload a new constraint to the platform. This flexible way of working allows a drone to be broadly deployable, in a variety of missions."

2. Environmental awareness: translating sensor data into safe behavior

Today, drones are equipped with all kinds of sensors to create environmental awareness. By making intelligent use of the sensor data, enhanced safety can be guaranteed.

"First, integrity checks have been implemented to accurately determine, at any stage of the mission, which sensors can be reliably used," explains project lead Ruben Smits. "This safety monitoring of multiple sensors is then translated into real behavior, for example by temporarily neglecting the data coming from sensors that have turned out unreliable. The developed solution is hardware independent." A typical example is localization, that is based on the combination of sensory data derived from multiple sources (such as gps, 3D cameras, gyroscopes, accelerometers, magnetometer). In the use case of pylon inspection, for example, high-voltage lines can easily interfere with gyroscopes or magnetometers, making the sensors temporarily unreliable.

Ruben Smits: "Besides, on-drone obstacle awareness has been implemented, based on an intelligent use of data from multiple sensors – such as 3D vision and ultrasonic detection. Sensor fusion allows the obstacles to be mapped, and these maps can be used as input for safe behavior. The drone will then 'learn' how to maintain distance or find a way around the obstacle."

3. Reliable wireless communication between a drone and a ground station

Safety can only be guaranteed if a reliable wireless communication network is established between the drone and a ground station. Today, drones are equipped with typically one communication radio, supporting e.g. the WiFi standard. Within this project, multiple communication channels, supporting different wireless standards, have been implemented on the platform. The performance of these channels is continuously monitored during the mission. When the active channel turns out unreliable, the system can seamlessly switch between communication channels. This redundant radio path for data transmission enables consistent and reliable data connectivity over the wireless network. In addition, techniques for load management have been added, allowing to prioritize wireless data or commandos in view of maximum safety.

4. Legal frameworks

The project has also addressed legal concerns, allowing the drone to operate within EU and worldwide legal frameworks. For example, forbidden zones and maximum authorized heights have been added to the constraints that determine the drones behavior. A main conclusion is however that not all legal concerns can be technically implemented.

NEXT STEPS

Tom Holvoet: "In general, the results obtained in the context of SafeDroneWare can potentially be used in various drone application domains. Here, they will help businesses maximize cost-effectiveness while using drones in compliant and safe ways. From a research point of view, however, the overall platform needs further development. Today, with the proposed framework, we can prove correct behavior of the drone, compliant with all specifications. But we cannot guarantee that the goal of the mission will be achieved at all times. This will be our main point of focus for the future." Ruben Smits: "We will look into the commercialization of certain sub-aspects of the platform – such as the monitoring of multiple sensors for improved localization."

FACTS

NAME	SafeDroneWare
OBJECTIVE	Architecture and framework for supporting autonomous drone behavior that complies with safety specifications
TECHNOLOGIES USED	Constrained based programming, automated planning, sensor fusion, on-drone obstacle awareness, vision based localization
TYPE	imec.icon project
DURATION	01/04/2016 – 31/03/2018
PROJECT LEAD	Ruben Smits, Intermodalics
RESEARCH LEAD	Tom Holvoet, DistriNet, an imec research group at KU Leuven
BUDGET	1,352,726 euro
PROJECT PARTNERS	Nimera Mobile ICT, Elia System Operator, Intermodalics
IMEC RESEARCH GROUPS	CiTiP - an imec research group at KU Leuven, IDLab - an imec research group at Ghent University, DistriNet - an imec research group at KU Leuven

SafeDroneWare project partners:

elia · intermodalics from software to robots · Nimera

The SafeDroneWare project was co-funded by imec (iMinds), with project support from Innoviris & Agentschap Innoveren & Ondernemen.

AGENTSCHAP INNOVEREN & ONDERNEMEN · Vlaanderen is ondernemen · innoviris.brussels

WHAT IS AN

IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and/or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

AMERICAS
raffaella.borzi@imec.be
T +1 408 386 8357

CHINA
timo.dong@imec-cn.cn
+86 13564515130

EUROPE & ISRAEL
michel.windal@imec.be
+32 478 96 67 29

JAPAN
isao.kawata@imec.be
T +81 90 9367 8463

TAIWAN & SE-ASIA
mavis.ho@imec.be
T +886 989 837 678

VIETNAM, BRAZIL, RUSSIA, MID EAST, INDIA
max.mirgoli@imec.be
T +1 415 480 4519