SPENCER Questions & Answers

What is project SPENCER about?

SPENCER is a European Union-funded research project that advances technologies for intelligent robots that operate in human environments. Such robots come in different sizes and shapes: guidance platforms at airports, domestic household assistance, care-takers for the elderly, collaborative production assistants in factories, or self-driving cars. Common to all of them is the need for new technologies that address questions such as: how should machines perceive and analyze humans with their sensors in order to act more naturally and unobtrusively? How can they learn and reproduce human social behavior? How should robots reason about actions among humans and communicate with users in ways that are socially-aware, safe, and efficient at the same time? By addressing these questions jointly and in an international multi-disciplinary team, the SPENCER consortium breaks new ground for understanding human-robot relationships and for designing effective cognitive systems in human-populated spaces. In short, SPENCER is about social robots "in the wild" – namely the extremely challenging environment of an airport.

Who is involved?

The project consortium consists of eight partners, six university partners and two businesses from five European countries:

1. Albert-Ludwigs-Universität Freiburg, Germany (coordinator)
2. Technische Universität München, Germany
3. Universiteit Twente, The Netherlands
4. Örebro University, Sweden
5. Centre National de la Recherche Scientifique CNRS, France
6. Rheinisch-Westfälische Technische Hochschule Aachen, Germany
7. BlueBotics SA, Switzerland
8. KLM Royal Dutch Airlines, The Netherlands

The project has been initiated by the university partners.

What will the robot do during the final demonstration?

SPENCER is a robot designed to help passengers find their way around the airport. KLM believes that robotics will have a growing impact on air transport in the coming years, for example for ground passenger services. At their home base Schiphol Airport, up to 70% of KLM's passenger traffic is due to transfer passengers whose efficient handling is a significant operational challenge. Every day, travelers miss their connecting flights for all sorts of reasons including delays, short transfer times, losing their way, and language barriers. To help these people, SPENCER guides transfer passengers along the shortest route to their departure gate. During the final deployment in March 2016, we will make tests with real passengers. This is a unique service, which we believe will lead to a new appreciation of the experience provided by KLM and possibly to a reduction of the number of passengers who miss their connection at Schiphol.

What's new in SPENCER?

Scientifically, SPENCER breaks new ground for cognitive systems in human environments. The scientific novelties are:

- **Social scene understanding for robots** by the abilities to perceive and analyze individuals and groups of people from on-board sensors and to recognize social relations, hierarchies and activities. These abilities enable the robot, for example, to detect people in its surrounding, estimate if they form a group and if yes, what the group is doing and who would be the best individual for addressing the group.
- **Learning socially normative behaviors for robots** by the abilities to acquire models of normative behaviors from demonstrated human behaviors and to use such models to plan its motions in human-friendly ways. These abilities enable the robot to be polite in the way it navigates among pedestrians. Couples or other groups of people, for instance, are not to be split up even if this was the shortest path for the robot to take. The robot also respects people's personal spaces. It can further decide to ignore social norms, for example, when it is guiding a group of transfer passengers in a rush.
- Other contributions include new ways to **learn maps of highly dynamic environments** that change over several time scales, to self-localize robots in such environments as well as **empirical experiments to assess the actual effects** of normative robot behaviors perceived by users.

SPENCER is the first socially-aware robot that has ever been deployed at an airport.

Where does the name SPENCER come from?

SPENCER is an acronym derived from the project's title **S**ocial situation-aware **PE**rceptio**N** and action for **C**ognitiv**E** **R**obots. SPENCER is the name of the project and the robot.

Are there other applications of SPENCER technologies, not at airports?

Yes, there are many of them. As is typical for EU-funded projects, SPENCER addresses fundamental research questions beyond a specific use-case. As there is a larger trend towards robots that share a space with people in domestic, professional, or urban environments, the technologies developed in SPENCER can be applied to a variety of cognitive systems in human environments. Examples include: domestic household robots, self-driving cars, robots in care facilities, collaborative production assistants in factories, transportation platforms in intralogistics, etc. All these robots need to perceive, analyze and model people in their surrounding, make predictions about their future actions, reason on their own actions and learn their probable effect on humans -- key challenges addressed in SPENCER.

Why is KLM part of this project and with its role?

KLM is the end-user in the project and provides a use-case which is both business-relevant and challenging for the technology developments of the university partners.

KLM's motivation to be part of SPENCER is a strategic one: the advent of robotics is an important development, for which the company has to be prepared. KLM is of the opinion that robotics will have a growing impact on air transport in the coming years. KLM is testing technologies in several areas to assess if and how robotics would enhance their services.

These developments are wholly in line with KLM's objectives with regard to innovation as one of the cornerstones of strategy. At KLM, the chief purpose of robotics will be to offer staff and customers even better support using innovative technologies.

Is it safe to operate a robot in such a crowded area?

Yes. For the consortium safety is the most important element of all. We have conducted many tests on robot safety using standard practices and protocols and improved the robot's hardware and software. All tests were successfully passed – a prerequisite for us to deploy the robot in a human-populated environment such as Schiphol Airport. In addition to the measures taken to make the robot safe, during the tests in March 2016, there is always a human operator near the robot with a remote emergency button to shut down the robot instantly.

What can you say about its trial run at Schiphol Airport in December 2015?

After a series of tests at the partner locations in Toulouse (F) and Freiburg (D), SPENCER was deployed at Schiphol Airport for the first time in end of November/December 2015. The airport is a particular complex and challenging environment for robots: changing light conditions and difficult surfaces in glass are problematic for its sensors, dense and highly dynamic crowds of people are a challenge for its perception, cognition and planning algorithms, and gate areas and walk-in shops that change their look several times per day pose challenges to its mapping and localization components. SPENCER was first overwhelmed by these difficulties and only many night shifts later, we had a fully working platform. The insights gained in these tests have enabled the consortium to further improve the robot and prepare for the final demonstration in March 2016.

Why a robot and not a navigation systems such as the ones in mobile phones?

Navigation systems in mobile phones do not work indoors, and only a robot could transport luggage, for example, and provide a unique user experience.

Also, a mobile robot is much more convenient than a navigation system on a phone: you only have to follow it, and you can use your phone for other things. Guidance is intuitive. Interpreting the instructions of a navigation system requires more attention than just following a robot. An autonomous robotic platform can address and guide groups simultaneously. Furthermore, a mobile robot gives the provider the opportunity to keep all services on his side, e.g. no app must be downloaded and installed, software maintenance and versioning is easier, etc.

What happens after the project ends?

The outcome of a research project like SPENCER is typically not a market-ready product but a prototype suited to conduct scientific experimentation and first proof-of-concept tests. The consortium, and in particular end-user KLM, will evaluate the robot thoroughly during and after the final demonstration. Depending on the outcome, KLM will determine with the project partners how to proceed.

What challenges remain?

At the end of SPENCER we have gained unique insights into the research questions we initially sought to answer. At the same time we are seeing plenty of even more intriguing questions for future research. They include soft mobile robots which are a class of robots made of soft materials. The robot would imitate a key feature of the human body, namely cushioning and compliance which would render it safer and would allow for even higher operational speeds among humans. Another line of work is an even more powerful perception of the robot's social context towards a deep understanding of what could be called social scene understanding. The difficulty with robots versus, for instance, networks of stationary overhead cameras like in visual surveillance, is that the robot senses the world from a shaky first-person perspective with limited sensing and limited onboard computing but loads of objects and people that occlude each other. Understanding context is key for reproducing socially compliant robot behavior: in very dense crowds, for instance, physical contact may be tolerated to some degree whereas in spaces with few people it is considered awkward. Speaking of context, cross-cultural aspects play a very important role in the design of socially normative robots which we have not systematically addressed in SPENCER. Of course, we see new research challenges also along the lines of more cognition, learning, interaction and navigation.

What needs to be done to make SPENCER a product?

Another great challenge is a commercialization of the SPENCER robot in case of a positive evaluation at and after the final demonstration at Schiphol. This would require to make the robot cheaper, safer, more light-weight, and smaller. We would have to make our algorithms more robust with fewer sensors and less computing power while interaction with the robot would have to be even more appealing. We have learned many lessons in SPENCER on how to do that. The gained insights enable us today to specify and prioritize many of the remaining open points.

How interactive is the SPENCER robot?

The robot carries a boarding pass reader which provides names and travel destinations of the passengers that interact with the robot. A touch screen shows additional information, such as time and distance to their gate. Then, during movements, the robot uses its head and eyes to communicate motion intent -- which was particularly appreciated by the participants in our studies. SPENCER communicates in English and can beep but currently uses those modalities only to excuse itself when it is blocked or if surrounding people cause the robot to take a large detour.

Engaging more sophisticated verbal interaction with the robot was not the focus of the project and would also be hard in a multicultural, noisy environment like an airport. Finally, the robot's task is guidance of transfer passengers who have to catch a connecting flight under time pressure. We believe that designing a chatty companion in this case would be the wrong interaction design approach.

Will SPENCER replace people?

No. SPENCER is a result of a research project and it is not near commercial use. We still need to do some more research and testing, before we can consider how to go further.