Introducing: SmartBot

Intelligent, autonomous, sensing robots and vehicles are becoming more and more common in automation paradigms worldwide. In addition to the more common industrial automation, agriculture and maritime autonomous solutions are rapidly emerging. These three areas are combined in the SmartBot project: a cross-border collaboration between a number of partners from Germany and the Netherlands. The SmartBot project consists of three sub-projects, aimed at the application of intelligent robotics in the shipping industry (RoboShip), agriculture (AgroBot) and the manufacturing industry (SInBot). Together, these projects aim to improve efficiency and effectiveness in their respective fields, in order to stimulate European businesses and reinstate internationally outsourced jobs.

SInBot

In particular, SInBot is aiming to reinstate manufacturing employment for small and medium-sized enterprises by improving the efficiency of industrial robots in performing small to medium-sized production runs. Nowadays, industrial robots are used mainly for repetitive work on large series (i.e. mass production). They perform their tasks efficiently, are cost-effective and moderately accurate. However, they have a long reconfiguration time, lack task flexibility as well as absolute accuracy. To improve the efficiency of these robots, SInBot plans to equip them with multiple sensors and let both robots and sensor networks communicate using a flexible ICT infrastructure enabling autonomous operation while performing complex tasks.

The tipper case

Project SInBot was proposed, in part, due to a burning question in the transportation sector. For example, Luinstra, a transportation and logistics solution company from Nieuwleusen, the Netherlands, is planning to manufacture fiber-reinforced polymer (FRP) lightweight tippers (dump truck beds; see Figure 1) in a mass-customisation setting. The manufacturing of these tippers is costly if done by hand and is therefore not economically feasible for European production.

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Luinstra’s FRP-tipper provides a case for smart robotisation. (Source: www.composittransport.com)
Luinstra is looking for ways to improve the efficiency of industrial robots working on large composite products. Since each unique tipper could be produced in series as small as ten, the robots should be flexible in task acceptance. Manufacturing large products requires long stretches of industrial robots, which further diminishes the feasibility of mass-customisation of FRP-tippers. Therefore, the needs of this company include task flexibility to improve efficiency in work preparation, as well as negligible reconfiguration times to decrease the amount of required industrial robots, the introduction of robot-robot and robot-human cooperation, and dynamic task reassignments to counter robot failure; see Figure 2.

**Objectives**

As a partial result from the Luinstra case, the main SlnBot objective is to develop industrial robots which are flexible, can work autonomously and are accurate without relying on the extended learning cycle associated with industrial robot work preparation. The robots should be able to cooperate and distribute the production tasks amongst one another. The system should be easily extendible to other robots (for example, automated guided vehicles (AGVs), industrial robots, or automated machinery) to increase the output, with more (or other) sensors to increase accuracy. Finally, the framework should be open, i.e. it should be possible to extend it with hardware from different suppliers.

**Approach**

A number of parties (see box) are working together on the SlnBot project to realise the aforementioned objectives. In this team, the academic partners focus on the algorithms and software structure needed to realise, among others, the cooperation between the robots and the translation from CAD data to actual production tasks. The industrial partners contribute their extensive knowledge of industrial production systems and environments. This combination of academic and industrial partners has resulted in the realisation of several demonstrators and virtual simulations to prove the feasibility of the SlnBot concepts in a real production environment.

**Challenges**

The realisation of the SlnBot objective is not straightforward; there are a number of challenges. Not only should the system work in a clean environment, but also in harsh production settings. The robots in the system should be able to work together, for example the robots decide which robot will perform which task, they can help one another, and should be able to stop working mid-task, for later completion by another robot. Therefore, the system should be flexible in task acceptance. For example, reconfiguration of manufacturing settings should be automated and fast. Finally, the system should be robust. If a sensor or even a robot breaks down, production should proceed normally, if possible.

To realise these tasks, a common framework will be used to translate CAD data to tasks for the available robots, keep track of the capabilities of the available machinery, create production tasks, divide these tasks using an auction model (which robot is doing what?), monitor these tasks and organise the communication between the different hardware components of the system. At the base of this common framework is a Data Distribution Service (DDS), used to keep track of all communication between the above mentioned tasks and the hardware.
To achieve the required task flexibility, the robots will be positioned on the desired production site by AGVs; see Figure 3. A combination of different sensors is used to position these AGVs. By using these partially redundant sensor systems, robustness and accuracy can be guaranteed even if a sensor is damaged or its accuracy is limited due to environmental conditions. If large production parts need to be moved, multiple robots should be able to work together. Coordinated motion (i.e. moving in formation) is required to perform this type of task. Robust algorithms will be developed that are capable of functioning properly even if sensor accuracy is limited.

Obtaining the required absolute accuracy is probably one of the biggest challenges associated with this project. The absolute accuracy of industrial robots is not always adequate to obtain the required process accuracy. This is not a problem in mass production because a long robot learning and reconfiguration cycle is allowed. However, this approach is not economically feasible for small series. Therefore, SInBot is looking for a way to correct the tool trajectory online. This requires fast and accurate (tolerances less than ±0.1 mm) sensor systems that communicate directly with the industrial robot controller, and can rapidly correct tool speed and direction. Multiple robots will be in use in the production plant of the future. These robots will cooperate and interact with humans. Thus, the robots should be able to work safely in an environment with moving (and fixed) obstacles. A combination of sensors, software and hardware must guarantee a fail-safe system.

Conclusion
SInBot is a significant research project with challenging objectives. Much work still has to be done, but the big picture has become more focused. The system architecture has been defined and a number of small demonstrators are already operational in the laboratories. The next steps will include the integration of multiple sensors, the demonstrators, and the software framework. At the conclusion of the project in December 2014, SInBot aims to prove the feasibility of mobile, (task-)flexible, accurate and robust robot manufacturing systems; the future of industrial robots is about to become much clearer.