This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723583

RE^4 Project

REuse and REcycling of CDW materials and structures in energy efficient pREfabricated elements for building REfurbishment and construction

D2.4 Classification and sorting by using NIR sensors and robot – publishable summary	
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[1] *Just mention the partner(s) responsible for the Deliverable*
[2] *PU: Public, RE: restricted to a group specified by the consortium, CO: Confidential, only for members of the consortium; Commission services always included.*
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General Goal of the deliverable

Deliverable 2.4 *Classification sorting by using NIR sensors and robot* is one of the confidential reports within RE^4 project, and was finalized and submitted on July 2018, under the responsibility of Stam. The document reports the research and development activities performed to develop a fully automatic robotic sorting system for CDW particles. The sorting system is based on hyperspectral inspection of materials in real time and uses machine learning logics for automatic classification. Preliminary tests performed in a laboratory environment are also reported together with an overview of the future industrial validation of the system.

The need

According to the proposed workflow of the project, RE^4 consortium aims at setting up a completely circular lifecycle for buildings, starting from the treatment of Construction and Demolition Waste (CDW) to give it a renewed technical value, in order to develop a new concept of prefabricated elements and install them on a new building.

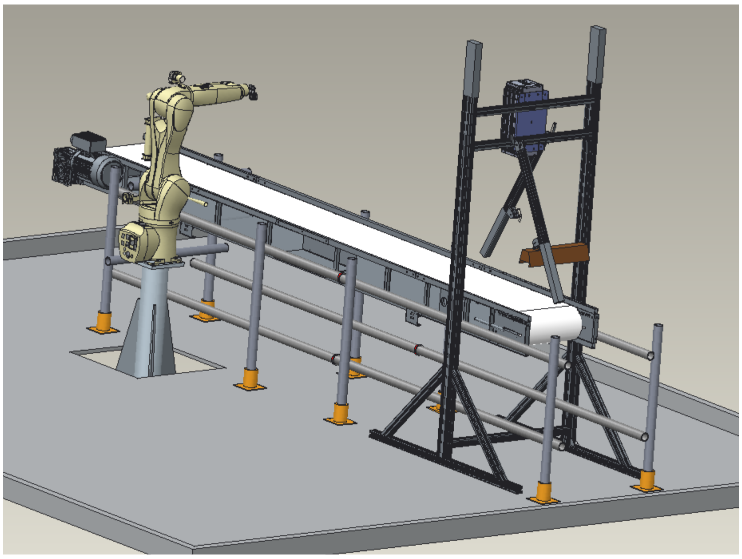

Figure 1: CAD model of the sorting cell

The work described within the deliverable is focused on the step of increasing the technical value of CDW. To do this, the main and most challenging phase of treatment is sorting the CDW according to the different composing materials. Of course, the goal of setting up a sorting system is twofold: first of all, the sorted materials have to be as much pure as possible, to maximise the quality of the final products to be developed by using them. On the other hand, the system has to be fully automatic to increase the productivity, minimise the processing costs and avoid any issue related to the manual sorting operations (human errors, health danger, etc).

Methodology and materials

The first phase of the work was focused on the definition of the functional and technical requirements for the CDW sorting system. In particular, it was found that the optimal concept design is a cell composed of a conveyor belt where the CDW particles flow at a known speed. By the inlet side of the belt, a structural gate had to hold the sensing components above the system. The cell is then completed by a robotic arm with a proper end-effector at the opposite side of the conveyor belt. Referring to the functionality and performance of the system, it was required that 6 different material classes were differentiated (stone, tiles, bricks, glass, plastic and wood), with a production up to 100 kg/h and a maximum contamination level of 1% by weight.

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The design phase for the system has comprised both a CAD modelling work for the structural parts of the cell (Figure 1) and the market analysis for the best components to fit the scope of the system. According to the CDW materials, fragments size (16-32 mm) and the aimed productivity, the following items were found as the best ones to be integrated all together:

- Sensor: hyperspectral camera working on a range between 950 and 1700 nm of wavelength, spatial resolution 35 µm, acquiring 256 spectral levels;
- Conveyor belt: length 4 m, width 40 cm, speed 0.114 m/s, PVC tape;
- Robot: 6 degrees of freedom, maximum pic rate 2.5 pcs/s, maximum payload 6 kg, pose precision 0.03 mm;
- End effector: based on vacuum generation exploiting Venturi effect, working at 5 bar with an air consumption of 200 l/min.

The following step was the integration of the components together with the development of the classification software architecture, which was entirely developed by Stam within its facilities, running on a dedicated control hardware. The robot trajectory control logics were developed by Stam as well.

Training session and commissioning

The development of the sorting system was followed by a campaign of preliminary tests at lab scale, with the final goal of assessing the functionality in a real industrial environment. In order to facilitate this step, a technical meeting was held in Genova, Italy, organised by Stam and attended by CDE's personnel, who was in charge of the industrial validation phase of the sorting process. The meeting focused on introductory training of CDE's personnel regarding the working principle of the machinery and the details of each single component. After a theoretical session on the working principle, the software architecture was presented by STAM, with main focus on the system logics, data communication and processes. Moreover, the system was practically demonstrated to CDE.

During the last period before the submission of the report, Stam and CDE together performed the installation and commissioning of the sorting cell by a CDW management site in Oxford, UK, to start to perform the industrial validation of the system.

Results and conclusion

The preliminary tests were mainly focused on the proper working of the system in terms of workflow and dataflow. The right communications between the different

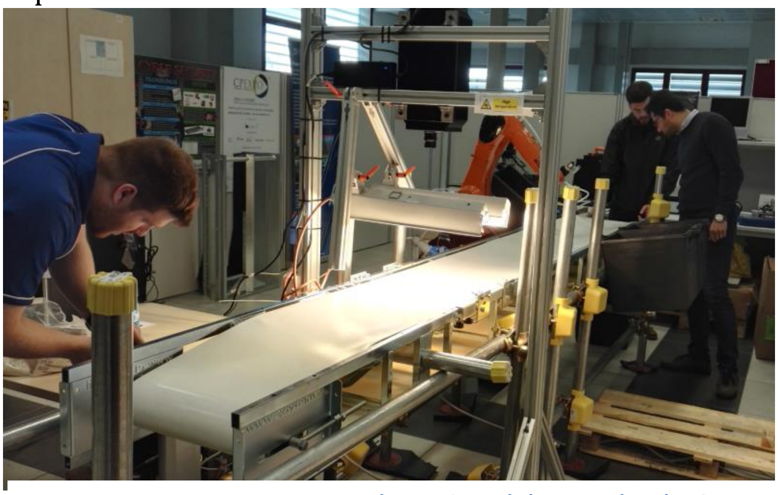

Figure 2: training session in Genova

blocks of the process were verified, from the transduction of hyperspectral signal, through the data processing and classification, towards the pick and place operations made by the mechatronic part of the system. Moreover, during the lab scale tests on the whole process, the speed of the sorting process was assessed by estimating its productivity which was found to be approximately 50 kg/h. This result is in line with expectations and is expected to significantly increase by using an industrial workflow with a proper CDW feeding system. Moreover, it was verified how the system is able to properly sort all the tested samples within the pre-defined material classes (stone, brick, tile, glass, plastic and wood). The next steps of tuning will be finalized to confirming these results in the operative environment.

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