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ConCreate

Executive summary

C&D Waste is the largest waste stream in Europe, with a value of approximately $126 million. The main issue of this market is the excessive use of virgin materials due to the high costs, and poor quality of the recycled resources. The challenge is to innovate the debris sorting and reusing technologies and to create an on-site solution to reduce transportation costs and process inefficiencies. To do so, robotics and automation are added to the equations, and the result is a high-performance 24/7 automated process.

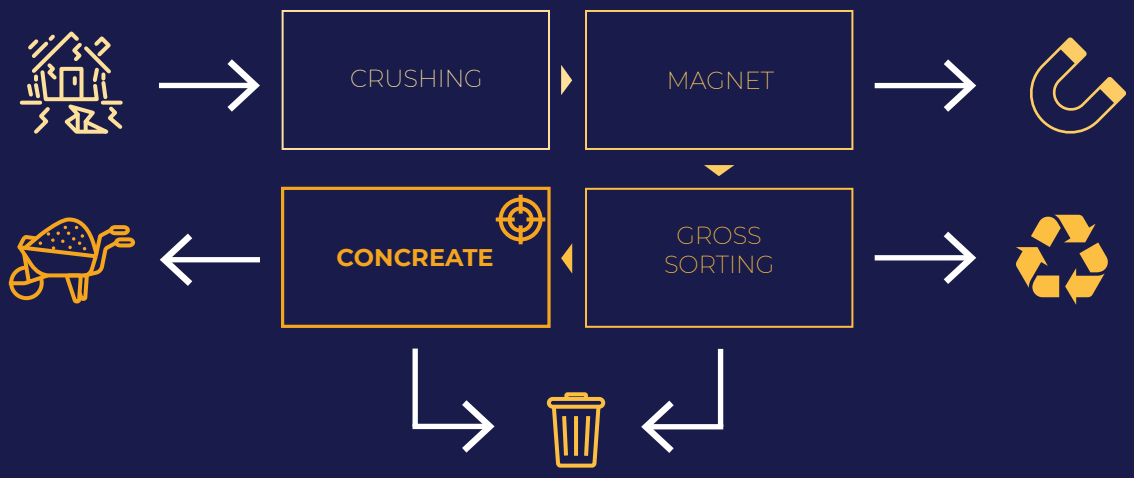
ConCreate is an automated sorting machine placed at the end of the crushing process to separate clean aggregates from wood, metals, plastics, and other impurities. The expected results are to cut the labor cost by two-thirds, reduce the transportation cost to zero, and promote a green circular economy in the C&D waste sector. All of this with a breakeven point of one year after the launch, and a Net Present Value of $4 million.

Key Words

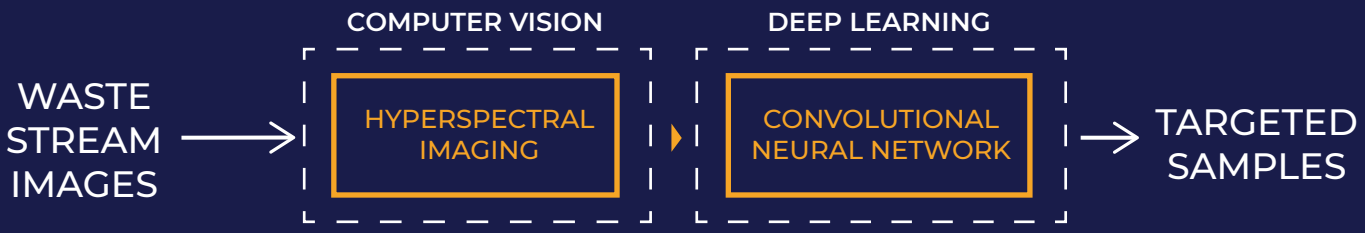
Waste, C&D, Sorting, Spectral Imaging, Circular Economy

CONCREATE
ROBOTICS

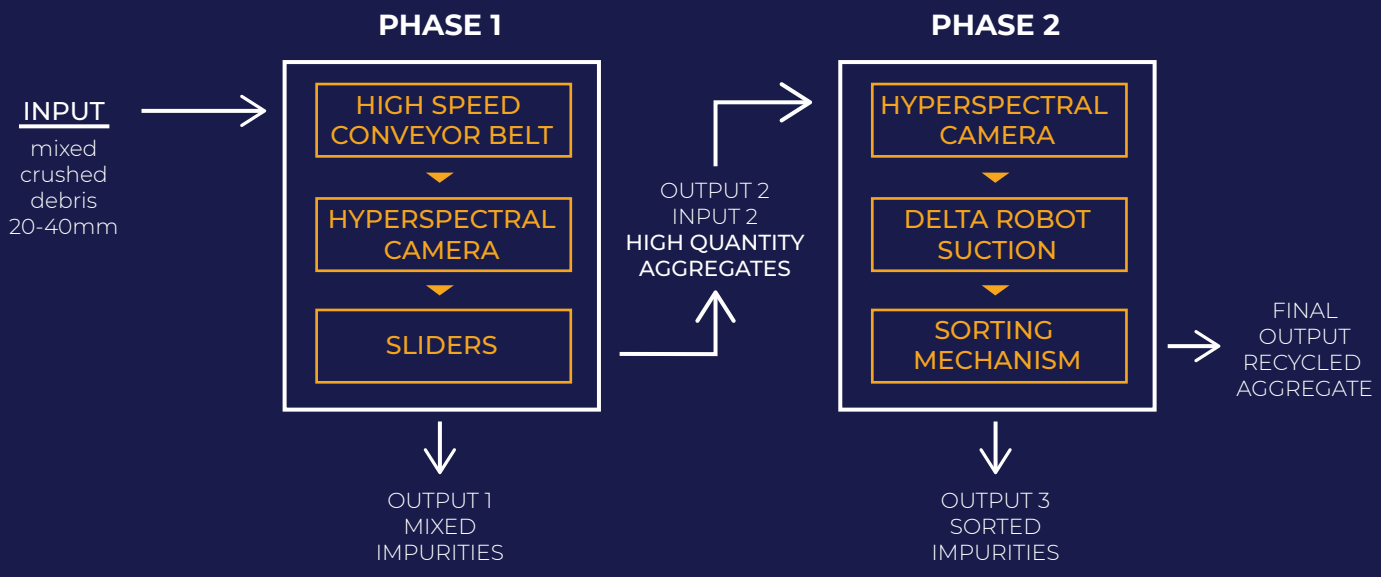
PROCESS ARCHITECTURE



SENSING ARCHITECTURE



HANDLING ARCHITECTURE



Project description written by the Principal Academic Tutor

The Construction and Demolition (C&D) field has shown to be a great business opportunity from the waste treating, reduction, and recycling perspective. Indeed, more than one third of the waste generated in Europe comes from demolition. However, despite the authorities' efforts towards an increased sustainability of C&D waste management, C&D waste is still downcycled to be used as filler for road foundations or abandoned quarries. One of the most limiting factors hindering a virtuous C&D waste management is the difficulty of properly sorting the large number of heterogeneous materials that are contained in demolition waste. The recycling process therefore ends up with large quantities of recycled material of low value, quality, and without a secondary market. Current technology and automation in the C&D field cannot guarantee a high enough quality of sorted material for the secondary market thus the process remains largely manual and the material unexploited leading to a dysfunctional market and landfills that are overflowing.

The ConCreate project aims at filling the gaps in the C&D waste management market by the design of a next-generation automated sorting system that takes advantage of latest achievements in computer vision and robotics to ensure high quality output from the C&D waste stream. After an initial requirement analysis with interviews to experts in the field, ConCreate has been conceived to be applied at the final stage of existing processes, i.e., after the debris flow has already been crushed and large impurities removed. ConCreate, at first, performs a rough preliminary sorting by means of a simple mechanism to separate pure aggregates from those contaminated with impurities. Contaminated aggregates then pass to the second fine sorting stage where they are sorted by means of a high-speed robot. These two steps produce high-quality output materials with high throughput rates. ConCreate differentiates valuable aggregates from impurities by means of a hyperspectral imaging camera and computer vision algorithms.

A preliminary market analysis has highlighted the commercial opportunity of ConCreate as we have witnessed a 300% increase in C&D waste production over the last 30 years. The value proposition of ConCreate, i.e., the fine selection of C&D aggregates, has the opportunity to address the broader issues affecting the C&D segment, namely, the lack of a secondary raw material market, the scarcity of new technologies and the lack of strong links between all actors in the value chain. For these reasons, the new approach has the potential to become the enabler of circular economy and deep-tech innovation in the field of construction and demolition waste management.

Team description by skill

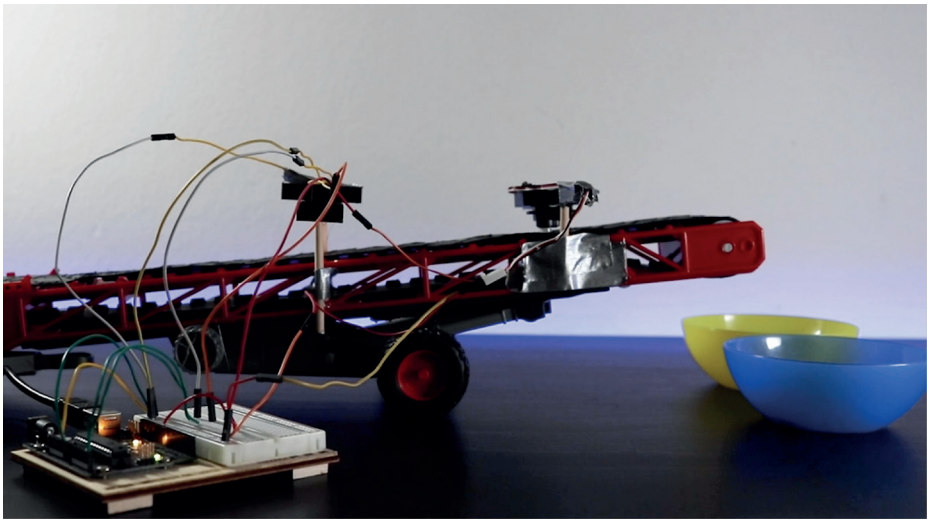
The team is made up of five engineers and one architect. Andrea Campanella is the Electronic Engineer, his electrical knowledge in the field of circuits and the Arduino systems has been fundamental in the prototyping phase of the project. Alberto Giarola is the Mechanical Engineer, his drawing skills using CAD software and knowledge of robotic applications were useful in the design process of the solution. Gabriele Goletto is the Data Science Engineer, his leadership and managing skills have been the greatest asset for this team, as well as his programming skills and knowledge of scanners and electrical components was essential to build the first prototype. Petar Knezevic is the Automation and Control Engineer, his wide knowledge for the automatic integrated robotic solutions and confidence with modelling software gave the team a great advantage in the rendering and designing phases of the project. Andrea Ottaviani is the Architect, his deep understanding of the construction and demolition materials and equipment was crucial, as well as his soft skills in communication and team building created a fertile and harmonious environment to work in. Giorgio Schembari is the Management Engineer, his economics and financial knowledge has made possible the feasibility of the project, while his leadership skills brought the team back on track in the most difficult moments of the journey.

Goal

The goal of the project is to completely disrupt the value chain by creating a technology that recognize different materials and sort them efficiently on a construction and demolition site. The barrier that the team aimed to crush are the high transportation costs of moving materials from the demolition site to the recycling one, the not environmental-friendly need to use virgin materials when building a new structure, and the predominant human component in the sorting operations that result in exhausting and repetitive jobs, as well as efficiency limitations due to the time shifts. At the same time, the team wanted the solution to be economically convenient with a prospected Break Even Point as low as two years.

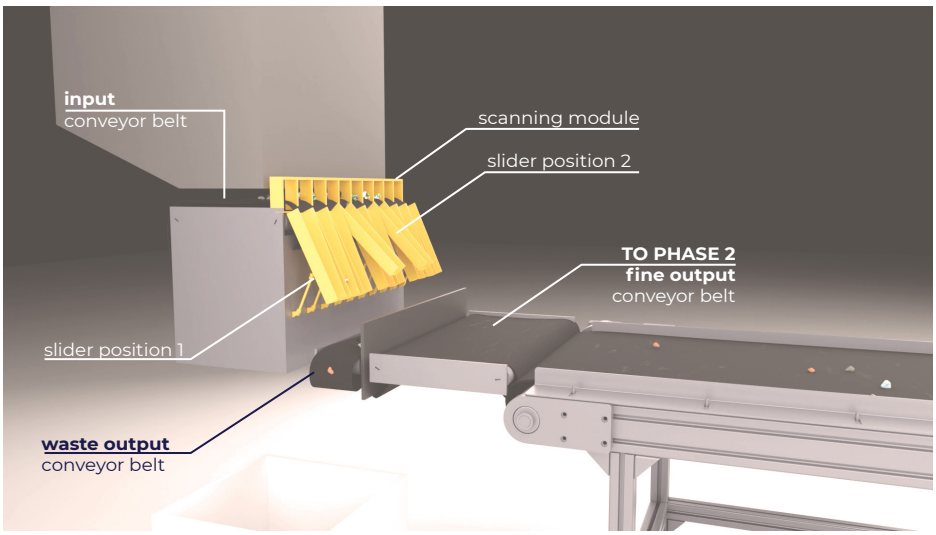
Understanding the problem

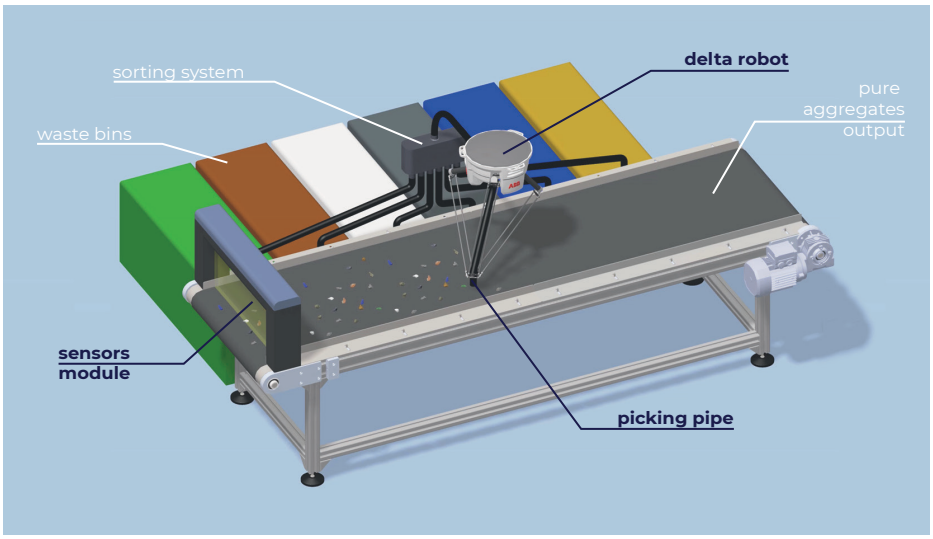
The main problem lies in the limited resources at our disposal. We rely on the unique properties of minerals, metals, alloys and fossil fuel but we usually forget that these resources are limited and their supply as well as their price are unstable. In the short term this can cause temporary out of stocks or increasing prices, but in the long term the consequences can be catastrophic. For this reason it is important to invest today in technologies that would preserve these resources tomorrow. The field that has been analyzed by the team is the construction and demolition one. The problem is the absence of an efficient circular economy where the waste of the demolition site becomes feedstock again for the construction of a new building. Demolition and disaster waste accounts for about one third of the overall trash generated in Europe, despite the goal set by the European directives to recycle at least 70% of these materials, the majority of the countries achieve this goal by downcycling the substances and using them for secondary purposes, e.g., fillers for road surfaces and not in the construction site.
In addition to that the way recycling sites treat the debris is far from modern, rough solutions are used to sort the debris depending on the physical properties and in the last phases manual help is still needed making this process not sustainable.
Construction companies with the willingness to use secondary raw materials have to face a higher price of the latter with respect to the virgin one and a lower quality so the market gets stuck and overloading of the sites happens.



Prototype developed by the team, testing the sensing technology in visible spectrum.

Rendering of first phase of ConCreate process





Rendering of second phase of ConCreate process

Exploring the opportunities

The construction market is growing exponentially in the last decades and the higher demand for virgin material is corresponding to a higher price of steel, wood, and concrete because of the limited resources of our planet. The greatest opportunity segment is the construction and demolition one, where sorting technologies are limited or not existing and the absence of a pure secondary raw material market forces the construction company to pay for virgin materials and the disposal of demolition waste. The opportunity is to interact with large companies that deal with the disposal of C&D waste but are not able to sell valuable products since the sorting process is so inefficient that the result is mostly similar to soil. It happens often that this stakeholders deal with the demolition and the transportation of the demolition waste as well, so it would be even more interesting for them to improve the quality of their sorting system and cut the transportation cost of moving the materials to the recycling facility.

Generating a solution

The design process started by analyzing the already existing crushing and disposal lines in different demolition sites to integrate the solution with them since a primary treatment on the debris is necessary in order to reduce the dimensions and make it treatable by robotic solutions. The solution generated by the team is ConCreate: a machine to be used in C&D waste recycling, in particular for the recovery of aggregates. The technology is placed at the end of the existing process, where washing, gross sorting and crushing have already been done. The input stream is therefore in small dimensions, where impurities are still present and usually cannot easily be removed. This system uses HyperSpectral Imaging cameras combined with a deep learning system, which can recognise the material on the conveyor belt and identify it. The targeted materials are then removed from the main flow through two different handling mechanisms. In fact, according to calculations, the system should be able to process more than 100 ktons of waste per year, which implies a high speed in the process. On the other hand, the objective is to achieve a high level of purity in the output materials. Therefore, the most critical requirement was to achieve the best compromise between sorting speed and accuracy. Consequently, the system was broken down into two parts. The first subsystem is used for rough preliminary sorting. It uses a simple mechanism to separate pure aggregates from those contaminated with impurities, allowing a high flow rate. Contaminated aggregates then pass to the second sorting stage. In this phase, the aggregates are sorted by a high-speed delta robot equipped with a vacuum suction system. This innovative system allows faster robotic handling and precise sorting. These two subsystems produce high-quality output materials with high throughput rates.

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