Data Mining Algorithms (32513)

ConstruClever: Intelligent Management of Surplus Materials in Construction

Presented by:

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IMPORTANT INFORMATION:

The link for the presentation video can be found under the following link:
https://youtu.be/boffCRzkq3Q

Aims, objectives and outcomes

Aim

The overarching aim of this project is to develop a system that can have a positive impact on the finances of the construction companies by helping them to manage their resources in a more intelligent manner and improving their savings.

Objectives

The objectives associated to the aim of the project are oriented towards its achievement by a staged execution; those are presented as follows:

- Identify the streams of resources that are not being managed appropriately in construction areas, as well as the disposition of wastage.
- Rigorously select the models that provide the most accurate results for the usage of such resources.
- Proceed with the deployment of the model in at least three companies of the region.
- Certify the benefits brought to the companies with the use of the resulting tool.

Expected outcomes

There are multiple benefits associated with the improvement of the resources management in the construction companies, and these can be stronger in the long term if the corresponding practices are adopted extensively.

Initially, several companies dedicated to the construction are expected to save millions of dollars per year only by keeping an eye on the materials used for their activities; which some experts can nominate as one of the reasons for constant money leakage inside large enterprises. In this case, by materials we refer to the incoming raw materials, leftover materials and debris (wastage), making reference to all the possible scenarios of the materials before and after use.

In second place, the involved companies would be able to maximise the utilisation of the materials in multiple ways:

- Control and appropriate storage of surplus material for upcoming stages of the construction project.
- Improvement of the disposal process of wastage and debris.
- Swapping, selling and buying processes of surplus materials, including the transportation and delivery tasks.

Finally, the most representative benefit can be reflected in the environment consequences from the dispose of materials and debris. By organising and managing this aspect appropriately, fewer resources are to be misspent, avoiding the nature to be impacted unnecessarily.

Background

Australia has been in a construction boom for several years, also by the hand of the mining industry, which keeps giving contracts for the elaboration of infrastructure in massive numbers. Independent of the actions taken by the mining sector, which is experiencing a slight fall since around four years ago (Letts 2016; Downes et al. 2014), the construction remains as one of the areas that are taking over several areas in the major cities of the country almost without any discrimination.

Like any other sector that contributes actively to the development of a region, most of the processes are standardised and guarded by the respective companies, boards and contractors. However, the case of the resources management is not as strict, and raw materials can quickly turn into waste without any supervision or serious guidelines that specify what to do in those cases; most of the times, this is left to the will of the labourers. Workers from overseas perceive this as an unusual practice for them, while stipulating that the management of resources in their countries of origin is a serious matter and is looked after very thoroughly; while it is true that there are some clear policies on waste management established by the Australian Department of Environment and Energy (2011), none of the regulations apply to material surplus management.

One of the reasons to which this aspect is attributed is the open budget given to construction projects in several cases; as such, the costs overrun are not seen as a problem as additional surpluses are expected once the project starts to recover the amount invested. This situation encourages managers and supervisors to ask for excessive quantities of materials, which in some cases are stored for extended periods of time, thus becoming obsolete. In other cases, some materials are disposed on purpose as the orders for the next stage have already been requested and there is not enough space in the cellars to keep the current material surplus available from the previous stage, and in fact, this can be seen as a management issue.

Some practices have been adopted to address this issue, particularly in Western Australia, Queensland and New South Wales; such operations refer to the utilisation of websites from Australian communities like Construction Sales (Construction Sales 2016), where construction companies, contractors and individuals can offer their materials available for sale or donation. A website in the United States (American Builder Surplus 2016) is oriented towards the attention of a community that sells and swaps construction surplus materials; this online community serves various major states and is associated with various national and state waste management associations. The limitations in the previous cases are that companies or individuals have to offer their materials explicitly, and no suggestions are given for buying, selling or swapping.

Academic resources are not extensive in this topic; however, some authors have made very useful contributions. Chen et al. (2002) introduced the application of barcode systems in Hong Kong for tackling a similar problem, thus reducing the waste coming from the construction sector. This application could be a complementary contribution to the proposed approach.

Project Scenario

Project Significance

The significance of this project comes from three different aspects which are interrelated and have a substantial impact on the sustainability of the industry towards the future; such aspects are the reduction of costs for the companies, the reusability of raw materials and the environmental impact from their disposal.

The reduction of costs that companies will experience will depend in this case on the management given to the raw inputs used for the different tasks along the project. As such, managers would be able to see some savings by using surplus materials that were not employed in previous stages of the same project, as well as they could see an income from the sale of those materials to other constructions that might need them.

The reusability of resources is closely associated to the previous point, particularly since construction firms would be able to know what to do with the raw inputs that were not used for a current task in the project; this will generate a positive impact on the finances of the company, which is the overarching aim of this project.

The last aspect regarding the significance of the project is oriented towards the reduction of the environmental impact caused by the excessive disposal of materials that still can be used. Establishing a connecting point between this aspect and the project exposed in this case, it is valid to say that as long as firms can give an appropriate use to their raw inputs and can exchange them with other companies, the rate of resources disposed will be lower.

Project Innovation

The innovation of this project is based on two primary aspects, which also make part of the plan to achieve the aim of this project; these topics are the collaborative approach and the reusing culture.

In regards to the collaborative approach, the innovation lies in the principle of "unity makes strength", which in this context means that companies can obtain remarkable saving benefits when they provide information about what they have and what they need; this allows the model to determine possible matches between firms requiring raw materials and companies having a surplus of it, allowing both to benefit from either purchasing materials for a lower price or selling materials that in the past were to be disposed.

The reusing culture will emerge from stakeholders committed with the reuse of resources and raw materials for future tasks by giving an appropriate allocation of the resources. One of the objectives associated with the project is to encourage reusing processes, stimulated by the financial benefits obtained in this situation.

Action Plan

Now, considering the objectives of the project and the expected results, it is important to define the tasks to be carried out achieving them. This project is to be divided into four main stages which will include several assignments each; some of them could be executed simultaneously by different teams in order to accomplish the schedule. Additionally, each stage will provide outputs and demand some inputs from the previous stages, in the case of the first one, the primary inputs will be to hire the necessary people for the respective tasks.

Research on Streams of Resources not managed properly

The first stage of the project is about making a precise definition of what raw materials are for our interests, and which are the critical ones for the outputs that need to be generated. In Project Management terms, the idea of this stage is to explore and understand more about the area to which this research is linked; as such, the pursued goal is to understand how the companies manage their inventory in order to determine they resources they have available and the raw materials they might need for next stages.

From this stage, the project will require the services of at least 6 Subject Matter Experts (SMEs) which will be allocated to the investigation and the proper knowledge transfer to the IT teams. In groups of 2 people, the SMEs will be in charge of research tasks related to construction workplaces, Waste Disposal Centres (WDCs) and statistics in general; the first group is expected to deliver a document explaining the materials tracing process in the areas where constructions take place, the second group will focus on how WDCs handle materials coming from construction and demolition, and the third group will study and gather statistics sourced by both construction areas and WDCs. These three groups are expected to work in conjunction, meeting periodically for preparing a document exposing the information collected and the possible datasets that can be sourced by the construction firms. The most important part of the labour undertaken by the SMEs will occur during this stage, and in the future stages, one SME from each group will accompany the tasks to be undertaken by the IT teams, keeping them focused on the overarching goal.

This stage is expected to take two months, and as such, from the fifth week, the IT teams will commence a training process that will help them to understand part of the problem, and get to explore the tools and materials to be used during the upcoming stage. During the second half of this stage, there will be no interaction between SMEs and IT teams as their tasks are different. In regards to the IT teams, the expected output is to show a decent understanding of the problem and a confident handling of the tools, whereas the SMEs team will deliver the main document and testing datasets.

Model Development

The stage of Model Development requires as input the two outputs given by the first stage. For the initial tasks, the IT teams and SMEs will have to join efforts to identify the data that is going to feed the model to be developed, by using the testing datasets sourced from the previous stage. Additionally, from the third week of this stage, a new team called Industry Contact (IC) will connect with multiple companies in the sector for gathering significant data in periodical basis; these pioneer firms will receive benefits from using the discoveries made by the resultant models. With all this in place, the teams will be settled down for taking over the respective activities and tasks during the first six weeks of the current stage.

One of the first tasks to be faced by the IT teams is related to the preparation of the data provided by the participant companies. This task requires a high attention level as the formats given by the different firms might vary, which proposes an additional challenge for this team as this is one of the initial filters to the information that feeds the model for the proper classification of data points.

This project is expected to work with the information provided by ten different firms, and as such, two engineers will be allocated to work on the continuous preparation and verification process of the incoming data, additional to the tasks related to building and testing the model.

Concerning the Data Mining process, the problem associated with this project can be labelled as a classification issue, primarily as the intention is to determine the best option available for a specific amount of surplus material. As an additional component, the classification will be performed taking into consideration the information provided by other companies, where variations in the data provided can represent significant changes in the final decision. The previous point exposes the high sensitivity of the model in regards to the information sourced; nonetheless, for reducing the risks associated with this aspect, the particular models will be feed preferably every week. Additionally, a continuous evaluation process will be periodically applied to the models.

Concerning the proper development, the classifiers are expected to be developed using R scripting embedded into KNIME, which is a tool that allows a more flexible management of the information flows and variables involved despite its technical complexity. The preparation and cleaning process can be performed by using KNIME as it is more straightforward and does not require extensive coding.

Due to the time taken by KNIME for loading the workflows, one server will be dedicated to hosting the application so that developers can access them directly, avoiding the hassle of waiting for an extended period. A second server will be devoted to the storage of the information sourced by the different firms, and eventually, a third server will be purchased

for hosting the application to be used by the companies depending on the capacity managed by the other servers. All those servers will be considered within the budget.

Generally speaking, this phase is expected to take as much as 7 months. From month 1 to 5, the construction and refinement of the final model will take place, and the development of the final tool is expected to begin in the last week of month 4, including testing sessions. Around 20 IT experts, 3 SMEs and 5 Industry Contact Assistants will be involved in this phase, and the numbers can increase for the following stages depending on the growth of the model.

Deployment of the Tool

Once the model is recognised as completed, the next step is to officially release the tool for its use in the pioneer firms. The expectation is to provide a website that can be accessed from a standard browser, only by members and authorised users. The tool will be released at the beginning of the tenth month of the project, and the personnel in the respective companies will be given access since then.

The deployment stage will start with the release of a document that explains how to use the tool and other aspects related to a proper use and how to exploit better the functionalities of the same. Participating firms will receive both digital and printout copies of this document on the same day the tool is released. This document will also contain a chapter with the improvements identified for the particular form during the construction of the model.

As the Model Development stage is finished and only incremental additions are to be added to the model, most of the members of the IT teams will be available to assist the support activities needed by the tool; additionally, attending requirements, solving questions and tutorials can be followed by them. New requirements identified have to be documented and notified to the team leaders so that they can organise the respective development tasks.

Certification of Benefits

The certification of advantages associated with the application of the tools developed from this project is a process that should take 1 month and is based on the first 2 months of operations (previous stage) in each of the participant companies. This certification will seek significant improvements in the savings for the companies, and if possible, to obtain an official standardised certification in such regards

Despite the time allocated to this stage within the project timeframe, this is an ongoing task that discloses the corresponding results every month. For this first iteration, a group of 5 Certification Experts will be hired from the second month of the Deployment stage; their associated tasks will encompass the familiarisation with the tools, creation and evaluation of metrics, gathering of relevant information and production of reports; additionally, other tasks out of the scope of this project will require the acquisition process of official certifications.

Timelines

As it was exposed in previous sections, this project is expected to run during one year in 4 different stages, summarised as follows:

- Research on Streams of Resources: 2 months
- Model Preparation: 7 months
- Tool Deployment: 2 months
- Certification of Benefits: 1 month

Each stage requires some specific tasks, some of them related to the preparation of the upcoming stages, but still considered within the current stage in terms of time and budget.

The closure of each stage has to be officially determined by the Project Manager, after certifying the delivery of the respective outputs of each stage and approving the results in each case when satisfactory. For simplicity, in regards to time and budget, additional time and costs are considered in general terms of the project instead of individual stages.

The Gantt chart exposing the tasks and their duration is shown in *Appendix A*.

Project Inputs

Budget

The budget presented in the table below considers the various costs associated with the project in all aspects. The main categories are highlighted in blue, and specific details are shown underneath.

Category	Cost/day ($A)	# Days	Cost ($A)
Venue			
Rent	400	336	134,400
Bills	20	336	6,720
Maintenance	15	336	5,040
Infrastructure	**Cost (Each)**	**Amount**	
Laptops	2300	35	80,500
Servers	4000	2	8,000
Screens	330	30	9,900
Software and Licenses	800	5	4,000
Other devices	50	10	500
Salaries			
Project Manager	750	250	187,500
SMEs (3)	1,950	250	487,500
SMEs – 1st stage only (3)	1,950	40	78,000
IT team leaders (4)	2,240	230	515,200
IT team experts (16)	6,400	230	1’472,000
IC assistants (5)	1,400	220	308,000
Certification Experts (5)	1,800	40	72,000
Allowances (SMEs and PM)			
Transportation	80	40	3,200
Meals	120	40	4,800
Stationery	500	1	500
Totals			3’377,760
Contingencies (20%)			675,552
TOTALS (with contingencies)			**4’053,312**

Personnel

There are various roles that have to be considered for the success of this project. Initially, the Project Manager will be involved from the beginning until the end. Regarding the SMEs, three of them will be involved during the entire project, whereas the others will leave after the first stage. All the IT staff will join the project two weeks before the beginning of the Deployment stage. Finally, IC assistants will be appointed from the third week of the Deployment stage onwards, whereas the Certification Experts will start only in the last stage of the project.

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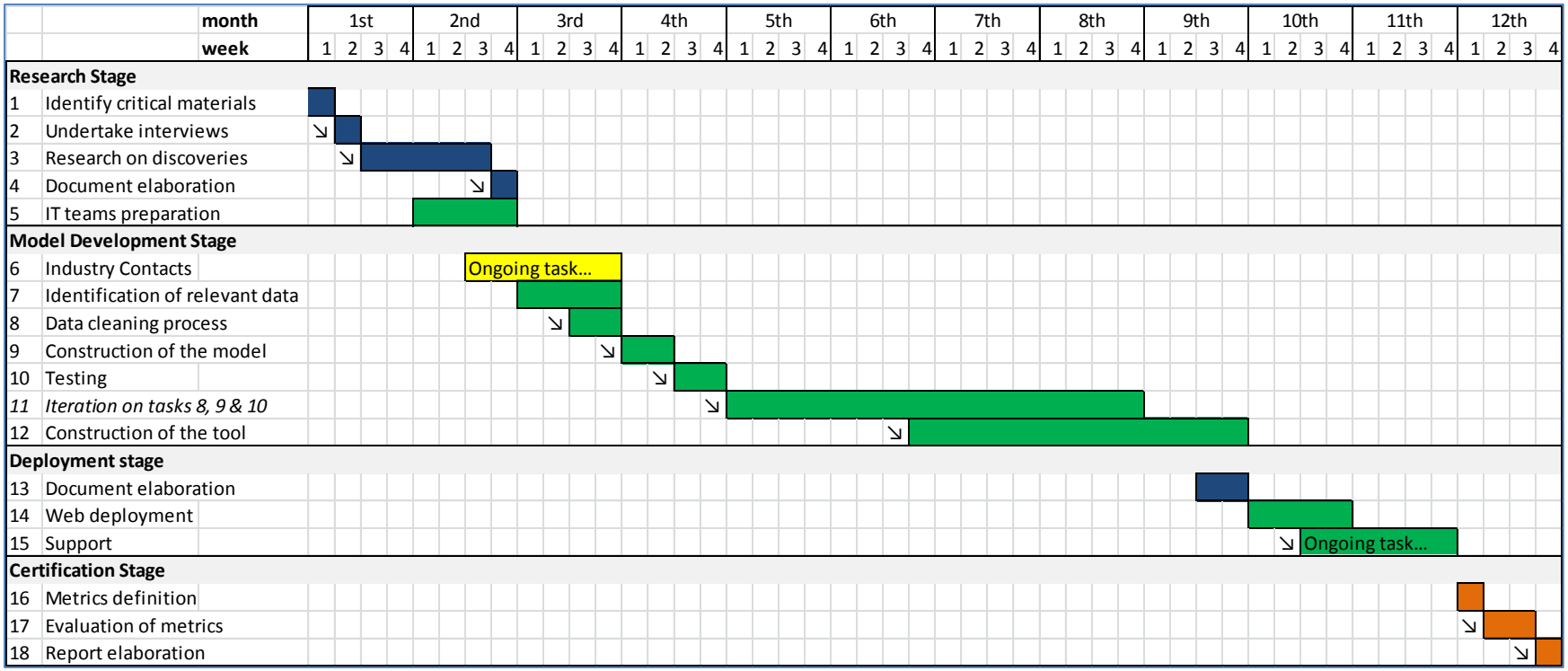
Appendices

Appendix A



Main responsibilities in each task:

- SMEs
- IT teams
- IC assistants
- Certification Experts