octavius

Machine Learning

Can Project Outcomes Be Predicted Through Machine Learning?

To what extent are project outcomes predetermined or predictable from project attributes? This is the subject of a fascinating and innovative research project led by Octavius Head of Strategic Projects, Will Hughes.

The study uses 'machine learning' (a branch of AI / statistical learning) to learn the relationships between project attributes (features) and eventual project outcomes. A clearer understanding of these relationships opens the possibility of more effective earlier interventions to improve outcomes such as safety incidents, delivery efficiency and profitability.

The hypothesis behind the 2021 research project was: 'can safety incidents and poor profitability (performance) of an individual project be predicted using just the known project conditions/ attributes and other regularly available data?'

In other words, can a 'trained' model be applied to predict outcomes on projects in progress? If so, effective interventions could then mitigate or remove potential project issues and maximise opportunities.

Summary Conclusions

The research study concluded that Octavius project data does contain information useful in predicting safety and profitability outcomes. It identified the most predictive attributes to use along with successful machine learning models whose predictions of safety and profitability outperform pure probabilistic methods.

The models developed in the study could correctly pinpoint specific projects at risk of below target performance. In other words, the data Octavius holds is informative when correctly prepared and analysed.

'Project Conditions'

'Project conditions' means knowable project facts like 'contact type', 'customer type', 'method of measurement' and Octavius assessments like 'governance risk level'.

It also means outcomes from management choices such as:

- Number of SC packages.
- % of project T/O spent on staff.
- Number and type of resources deployed.

Additionally it includes external or emerging / consequential factors such as 'early warning notices', 'extensions of time', 'staff continuity' and 'safety incidents'.

Research Methods

177 completed projects were identified for inclusion, where existing project data was reasonably robust. The projects had been 'on-site' at some point during 2019 to 2021. They were completed after September 2017 and before February 2021.

The academic literature for safety and performance prediction was also reviewed to identify likely 'predictive' project attributes.

The main Octavius data sources were then reviewed to identify which of these 'predictive features' existed, or could be reasonably computed from the existing data.

The data sources used were:

- Spreadsheet of Monthly Project Reviews (MPR) performance data.
- Cost Value Reconciliation (CVR) and Management Accounts commercial data.
- Document Management System project and bidding data.
- Accident and Incident database.
- Improvement Opportunities database.

A unifying project identifier was created and used to link all the data sources. Monthly type data was 'rolled up' using consistent rules to produce final project outcomes (e.g. 'number of safety incidents during the course of the project' or 'duration on site').

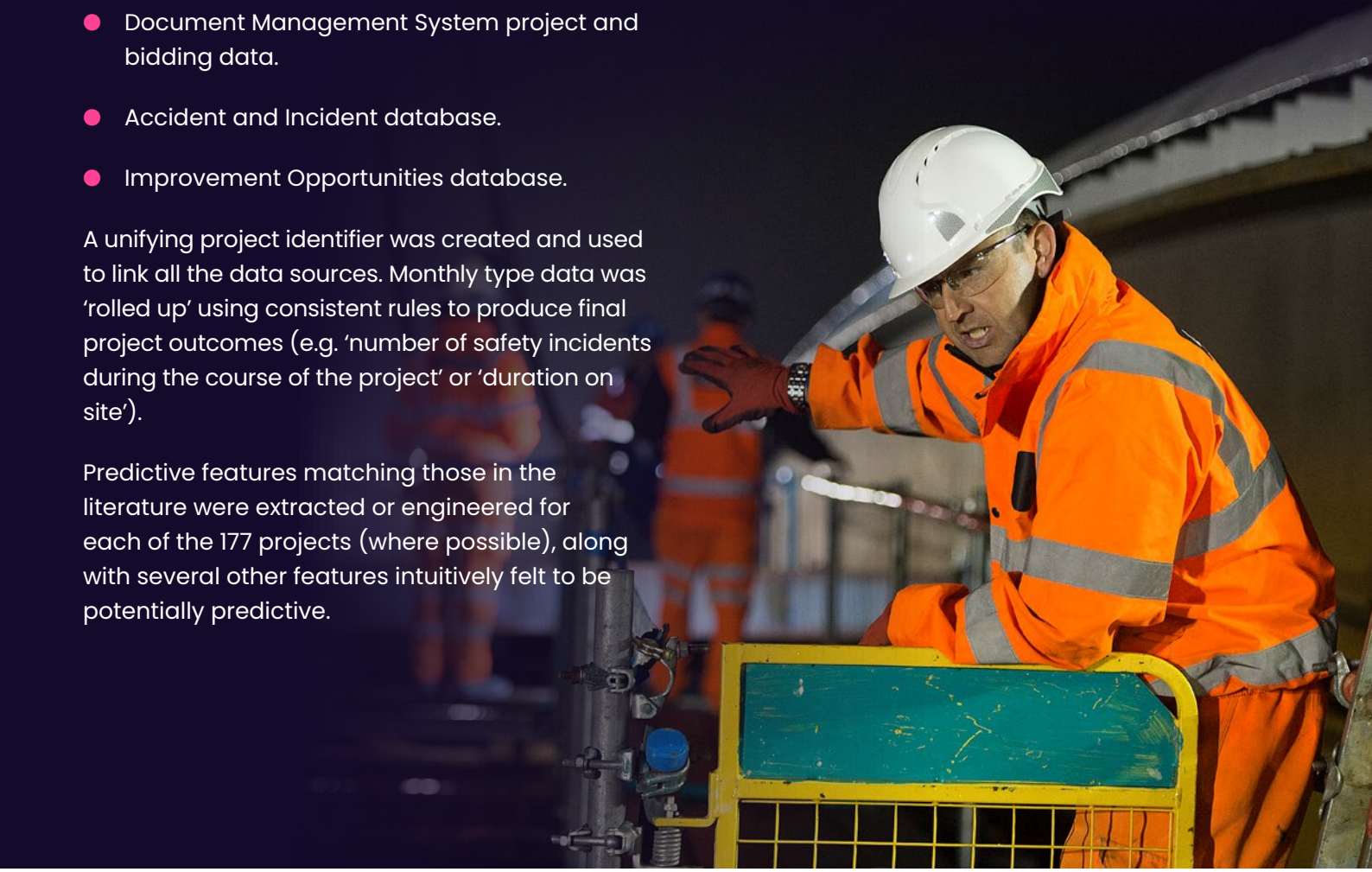
Predictive features matching those in the literature were extracted or engineered for each of the 177 projects (where possible), along with several other features intuitively felt to be potentially predictive.

Predictive Project Features

Around 50 features were identified to predict safety incidents, and a further 50 to predict lower than anticipated performance. Some features from the literature could not be engineered or extracted.

Some data engineering was done in consultation with subject matter experts, and some using the researcher's knowledge and experience. Inevitably some engineered features may not reflect reality in all cases. An example would be choices made when handling conflicting data or when identifying groups of sub projects that go together.

Correlation coefficients were computed between each feature and actual project outcomes to see which had the strongest association. This confirmed the features identified in the literature have predictive power in the context of projects typically undertaken for Octavius customers.



Project Outcome Predictions

The 177 selected projects were split into two groups

- 132 used to train predictive mathematical models.
- 45 projects were used only to test the predictive power of models.

These models 'learned' the association between the features and outcomes on the 132 training projects and were then tasked to predict the outcomes of the 45 test projects, only using the input features.

Their prediction success rate was superior to probabilistic 'guessing' and better than baseline predictive models. The models achieved around 80% accuracy in predicting Gross Site Margins (GSM) and Safety outcomes on completed projects.

Adoption And Development

The original predictive (2021) Machine Learning model used 'Target GSM' derived from the CVRs and compared it to 'Actual GSM' derived from the Management Accounts for completed projects.

The object was to learn which features were associated with a project achieving or failing to achieve its GSM target.

In the current (2023) adoption trials we re-interpreted the machine learning model outcomes to produce a simplified inference (prediction) model using a subset of project features derived from data that is easiest to obtain. This approach was selected for speed of implementation and ease of regular reporting, but it comes at the expense of some predictive skill.

The 'simplified model' outputs a class prediction: 'meet target'/'fail to meet target.' It also identifies the strength of the prediction or 'certainty.' The accuracy of these strongest predictions is similar to the accuracy achieved by the original full model across the whole data set.

Outcomes And Next Steps

The current 'simplified model' is working. We can now reliably produce a set of predictions each month using a process that is not too onerous or resource intensive.

A development objective is to investigate how project outcomes compare to 'tendered GSM.' This is subtly different to the CVR 'target GSM' that our original machine models were trained on.

The original model was not trained or tested on projects in progress, which is what we now want to predict. Therefore, the 'in progress' projects at 2021 whose outcomes are now known were analysed using the original and new simplified machine models.

Using the 'features' weightings at the time (2021) the model accurately predicts 73% of the outcomes. Using the weightings in place today with 2021 data, the machine model accurately predicts 80% of the outcomes.

Currently in-progress project prediction accuracy has only been tested by comparing the predictions from the simplified model against current GSM and against commercial director human prediction. Those tests showed around 75% prediction accuracy where the machine model was 'certain' – nonetheless the final actual project outcome data is not yet known.

The genuine machine learning model predictions contained a much higher proportion of confident predictions than the simplified model. We are retraining the original machine models on the data we have available now (a more limited data set, but still powerful enough features).

This should allow us to improve predictability on certain defined classes of project - helping us work safer, provide industry-leading certainty and continually improve the efficiency and effectiveness of our services to customers.

At Octavius we believe Innovation is driven by culture not a department. If you'd like to know more about our innovation strategies, contact: hello@octavius.co.uk