MONTANA Department of Transportation
Research

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Project Summary Report
FHWA/MT-23-001/9929-819

# ARTIFICIAL INTELLIGENCE (AI) BASED TOOL TO ESTIMATE CONTRACT TIME

https://www.mdt.mt.gov/research/projects/const/ai_based_contracting_tool.aspx

## Introduction

MDT is in the process of modernizing their contract time determination processes by developing user-friendly tools to facilitate the estimate process of project duration and contract time. As part of this modernization effort, a top-down project duration estimation tool was developed in this research project.

This tool is particularly useful when there is limited information available during the early preconstruction stages. This research project involved the development of an Artificial Intelligence (AI) based model that can predict the most probable duration of a construction project using an early cost estimate, major controlling work items, and their estimated quantities as input values. Additionally, a regression model with the same set of input variables was developed as a companion to the AI model. The models were trained and tested using the historical project data of more than 1,000 highway projects from 2008 to 2019. In order to operationalize the models, a user-friendly Microsoft Excel tool named AI-PDET (Artificial Intelligence based Project Duration Estimation Model) was created (Figure 1). AI-PDET can be used throughout the preconstruction phases to quickly determine a reasonable project duration for proper project planning and delivery. Furthermore, it can serve as a reality check tool alongside bottom-up tools during the procurement stages.

## What We Did

The research project was accomplished through the following Tasks:

**Task 1:** The research team reviewed leading practices in other DOTs in terms of project duration estimation tools. The weaknesses and strengths of those tools were analyzed and documented. Key project characteristics that are associated with project duration were identified. State-of-the-art techniques in AI for project duration estimation were reviewed as well.

**Task 2:** The research team collected historical project data of 1,090 highway projects from MDT spanning from 2008 to 2019. Data attributes included project numbers, location (urban/rural), bid price, project duration, adjusted construction cost, charged days, work type, letting date, bid item (work item) and quantity of work.

Projects were divided into 24 different work types. Histograms of project durations and project costs were developed to understand the characteristics of MDT highway projects. Bid days were compared to actual project durations to evaluate the accuracy of contract time estimation reflected in the bid days.

**Task 3:** The research team developed an Artificial Neural Network (ANN) driven AI model that receives

project characteristics and predicts the project duration. A linear regression model was also developed to be compared with the ANN model using Mean Squared Error (MSE) and R-squared. Comparative analysis revealed that the ANN model outperforms the linear regression model. Feature selection was conducted to keep important features and eliminate insignificant features.

**Task 4:** Using the findings from Tasks 2 and 3, the research team developed a Microsoft Excel-based tool, named AI-PDET (Figure 2). Both ANN and the regression models were embedded in the tool. The tool takes important project features such as the estimated construction cost, and the quantities of major work items to predict the project duration based on both ANN and linear regression models. AI-PDET provides three sample projects from the database as examples for the user to understand how to use the tool.

A meeting with the MDT technical panel was conducted to present the tool and discuss the results. The MDT panel suggested that the research team should provide guidance on how to update the models and the AI-PDET in the future when new project data becomes available to keep the models and the tool up to date.

**Task 5:** In this task, the research team created a comprehensive project report explaining all tasks and outcomes in detail. Other deliverables, such as a project implementation report and a poster, were developed. A chapter in the final report was provided to describe all steps and procedures required to update the models and the AI-PDET in detail. To facilitate updating the models over time, a thorough description of the programming part was included in the chapter.

## What We Found

**Bid days in comparison with charged days:**

Bid days were compared to charged days using the percentage of difference of the two, which is

(Charged days-Bid days)/(Bid days)*100.

The analysis result shows that projects with bid days less than 40 days, (short term projects) tend to get finished 24% sooner than estimated. However, projects with bid days greater than 40 days tend to get delayed. For example, Projects with bid days between 120 and 140 days were on average, delayed for 22% more days than the original bid days.

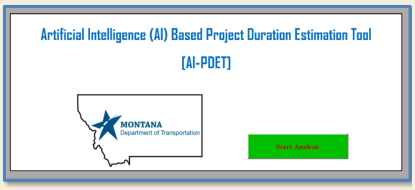


**Figure 1:** *AI-PDET*

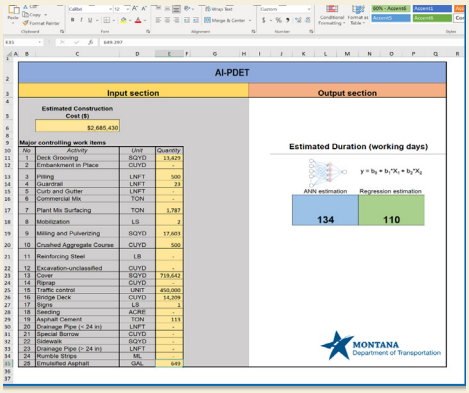


**Figure 2:** *AI-PDET – Input and Output Screen*

**Significant Variables:**

The relative importance of project variables such as project type, starting year, project cost, work item quantities, project type, and project location on project duration was analyzed using F-test. The result showed that only estimated construction cost and the quantities of some major work items were statistically influential factors on project duration. These variables were used in developing AI and regression models.

**ANN compared to linear regression for project duration estimation:**

An ANN model and a linear regression model were developed to predict project time. The ANN model appears to perform somewhat better when the performances of the two models are compared. To provide alternative predictions, both ANN and linear regression are used in the Excel tool. However, the ANN model is more preferable in project time prediction since it can recognize more complex relationships between variables.

**AI-PDET:**

The final models of ANN and linear regression were embedded in AI-PDET to operationalize the two models by creating a user-friendly interface. The AI-PDET includes a general guideline, computation sheets that receive inputs including the estimated construction cost, and the quantities of major work items. Sample projects were provided as examples to use and evaluate the models.

## What The Researchers Recommend

Based on the findings from this research, the following recommendations are made.

1. Use the AI-PDET as an early project duration estimation tool in the programming and the preliminary design stages. The level of accuracy of AI-PDET will be acceptable in these project delivery stages. However, when the project size gets larger with the estimated construction cost greater than $8M, a caution must be

exercised as the predicted project duration may not be reliable. It is because the majority of the historical projects cost less than $8M and the models were trained with the available historical data set. The prediction accuracy of a project that is not common or rare in the training dataset tends to be unreliable.

2. Use the AI-PDET tool as a back-check tool at the end of the final design stage to ensure that the contract.
3. Time in working days estimated by the scheduler is within the reasonable range of similar historical projects.
4. Regularly update the AI-PDET over time with new project data to enable the models to learn from new projects, improve the prediction performance and make AI-PDET relevant to recent projects.

*More Info:*

The research is documented in Report FHWA/MT-23-001/9929-819


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