ALBERTA INNOVATES

CLEAN RESOURCES FINAL REPORT PACKAGE

Project proponents are required to submit a Final Report Package, consisting of a Final Public Report and a Final Financial Report. These reports are to be provided under separate cover at the conclusion of projects for review and approval by Alberta Innovates (AI) Clean Resources Division. Proponents will use the two templates that follow to report key results and outcomes achieved during the project and financial details. The information requested in the templates should be considered the minimum necessary to meet AI reporting requirements; proponents are highly encouraged to include other information that may provide additional value, including more detailed appendices. Proponents must work with the AI Project Advisor during preparation of the Final Report Package to ensure submissions are of the highest possible quality and thus reduce the time and effort necessary to address issues that may emerge through the review and approval process.

Final Public Report

The Final Public Report shall outline what the project achieved and provide conclusions and recommendations for further research inquiry or technology development, together with an overview of the performance of the project in terms of process, output, outcomes and impact measures. The report must delineate all project knowledge and/or technology developed and must be in sufficient detail to permit readers to use or adapt the results for research and analysis purposes and to understand how conclusions were arrived at. It is incumbent upon the proponent to ensure that the Final Public Report **is free of any confidential information or intellectual property requiring protection**. The Final Public Report will be released by Alberta Innovates after the confidentiality period has expired as described in the Investment Agreement.

Final Financial Report

The Final Financial Report shall provide complete and accurate accounting of all project expenditures and contributions over the life of the project pertaining to Alberta Innovates, the proponent, and any project partners. The Final Financial Report will not be publicly released.

ALBERTA INNOVATES

CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	**Artificial Intelligence Assisted Computer Vision Application in Oil & Gas Mining Industry**
Alberta Innovates Project Number:	202101886
Submission Date:	**30/10/2022**
Total Project Cost:	**$536,120**
Alberta Innovates Funding:	**$375,284**
AI Project Advisor:	Claude Ghazar

2. APPLICANT INFORMATION:

Applicant (Organization):	**NTWIST Inc**
Address:	9650 20Ave NW, Edmonton, AB, T6N 1G1
Applicant Representative Name:	Chowdary Meenavilli
Title:	CEO
Phone Number:	780-807-4023
Email:	cmeenavilli@ntwist.com

3. PROJECT PARTNERS

Please provide an acknowledgement statement for project partners, if appropriate.

RESPOND BELOW

Organization Name
NTWIST Inc
Suncor Energy

A. EXECUTIVE SUMMARY

Provide a high-level description of the project, including the objective, key results, learnings, outcomes and benefits.

RESPOND BELOW

Visual inspection plays an important role in the processing of oil sands. An oil sands control room will typically have several video feeds that need to be continuously monitored; however, there are several challenges with this approach. First, since the visual inspection is qualitative in nature, operators are not consistent in how they interpret and respond to camera feeds. Second, the need for near continuous monitoring burdens control room operators. NTWIST proposes to use computer vision to address these challenges. Computer vision is a subset of artificial intelligence which enables the quantification of visual information. This solution is positioned to provide significant environmental and economic benefits to customers and strengthen Alberta's position as a leader in applied artificial intelligence.

B. INTRODUCTION

Please provide a narrative introducing the project using the following sub-headings.

- **Sector introduction:** Include a high-level discussion of the sector or area that the project contributes to and provide any relevant background information or context for the project.
- **Knowledge or Technology Gaps:** Explain the knowledge or technology gap that is being addressed along with the context and scope of the technical problem.

RESPOND BELOW

The first steps following mining of the raw ore in the oil sands are ore preparation and bitumen extraction. At the ore preparation plant, the raw ore is mixed with heated water to produce a slurry which is transported via pipeline to the extraction plant. At the extraction stage, bitumen is recovered while rejecting the heavy solids.

In each stage, remote visual inspection plays an important role. During ore processing, the raw ore is remotely inspected using cameras at the ore processing plant to assess the ore quality and respond with changes in the temperature and rate of water addition to the slurry. Ore grade has a significant impact on the achievable extraction rate downstream at the extraction plant since ores high in clay inhibit the bitumen from attaching to froth bubbles in the primary separation unit. During bitumen extraction at the extraction plant, cameras installed at the sides of the primary separation units are used to inspect the froth/middlings interface level, and respond with the changes to the rate that middlings are removed from the unit.

A technology and knowledge gap exists in how computer vision can be applied to improve the efficiency of processing facilities in the oil and gas industry. The tools needed to address these problems (the computer vision models and software platform needed to enable them to communicate with industrial equipment and control room software) do not currently exist. This project will advance NTWIST's existing technology to successfully demonstrate the commercial benefits of computer vision based tools in the oil and gas industry.

C. PROJECT DESCRIPTION

Please provide a narrative describing the project using the following sub-headings.

- **Knowledge or Technology Description:** Include a discussion of the project objectives.
- **Updates to Project Objectives:** Describe any changes that have occurred compared to the original objectives of the project.
- **Performance Metrics:** Discuss the project specific metrics that will be used to measure the success of the project.

RESPOND BELOW

Technology description

The proposed solution addresses two main problems in industrial control rooms : 1) the lack of consistency in assessment of remote visual feeds and 2) the difficulty in continuously monitoring remote visual feeds. These problems are the root cause of significant reducible GHG emissions and operating expenses. NTWIST's solution addresses these problems by extracting quantified metrics from video feeds using computer vision algorithms, and incorporating this data into an AI assisted process control platform. The use cases addressed here, specifically ore characterization at the ore processing plant, and froth/middlings level detection at the primary separation unit, help address key metrics of the bitumen mining and refining process.

The core computer vision algorithm for level detection at the primary separation unit was originally developed in collaboration with a commercial partner, CNRL. The computer vision algorithm is able to detect the froth/middlings level with a prediction accuracy of 62%, in line with the site glass levels in ideal conditions. The algorithm requires additional development to add robustness so that it will be practically useful. Integration into NTWIST's platform, and testing in an operational environment is also necessary. This remaining development and testing work falls in the scope of this project.

The ore grade assessment module has not yet been developed, but Suncor, our commercial partner, has provided NTWIST with preliminary data to assess the feasibility of the solution. Computer vision module development, integration with NTWIST's platform, and testing are all still necessary, and fall in the scope of this project.

Project objectives

The main objective of this project is that control room operators are provided with the data they need in real time in order to maximize the bitumen extraction and minimize operating costs for the ore processing and extraction stages of oil sands operations. This objective will also serve NTWIST's strategic objective of integrating advanced video analytics into its product offering.

D. METHODOLOGY

Please provide a narrative describing the methodology and facilities that were used to execute and complete the project. Use subheadings as appropriate.

RESPOND BELOW

NTWIST developed the solution using a modular software development approach. The two computer vision modules developed and tested independently and integrated into NTWIST's platform. Modules are first tested using historical data representative of the end-use environment. Once desired performance with historical data is achieved, the software modules are integrated into NTIWST's platform, which are connected to the live plant distributed control systems. The solution performance is validated against live data.

E. PROJECT RESULTS

Please provide a narrative describing the key results using the project's milestones as sub-headings.

- Describe the importance of the key results.
- Include a discussion of the project specific metrics and variances between expected and actual performance.

RESPOND BELOW

- Milestone 1- Project Scope

The project metrics and project scope with the Suncor project team has been confirmed. The project team finalized and confirmed the target key performance indicators (KPIs), scope of data collection, and baseline operating data window to be used for project evaluation. NTWIST worked with broader stake holders from Suncor to assess the business (ESG and Financial) impact.

- Milestone 2- Level Sensor

Go-live delayed by 3 weeks but no material impact on the project. The level sensor is deployed as a stand-alone module at the primary separation unit site.

- Milestone 3- Ore Characterization

Data collection batch program is delayed due to issues with Suncor network. NTWIST worked on resolving the issues. No significant impact is anticipated to project duration or scope.

- Milestone 4- ML Models

All the key support models such as truck identification, ore characterization, level recognition and auto window detection are developed to enhance the vision application using different error measurement methods. Model parameter tuning is performed to reduce the errors to an acceptable level. A communication interface and integration with control systems are created to prepare for the platform implementation of the AI software (application).

- Milestone 5- Platform ready for Go-Live

The platform is well tested with all the integration points and refined the machine learning algorithms with unseen data. Established a communication protocol with DCS from the AI platform is a necessary part of the technology development. Validation of the technology that includes quantification of errors with offline data.

- Milestone 6 - Go-live: Completed

The AI platform is connected to the live CCTV network, process plant DCS to utilize live plant data to refine the machine learning algorithms. Validation of the technology includes quantification of errors of the vision results against real-time operating data. The production implementation of the technology, the model predictions are validated and measured for a period of 30-days.

Please provide a narrative that discusses the key learnings from the project.

- Describe the project learnings and importance of those learnings within the project scope. Use milestones as headings, if appropriate.
- Discuss the broader impacts of the learnings to the industry and beyond; this may include changes to regulations, policies, and approval and permitting processes

RESPOND BELOW

F. KEY LEARNINGS

During image dataset production and analysis, NTWIST discovered multiple issues with the videos retrieved from the historian. For example, video feed is bad during certain time periods; measurements from mining data during some periods went missing. This required additional manual data processing and highlighted the need for meticulous data integrity verification to facilitate live data acquisition. This experience has led NTWIST to include earlier and more thorough data quality checks on future projects.

From a technical standpoint, NTWIST has gained key insights into the relevancy of different machine learning algorithms to the vision / image processing which is the focus of this project.

The most significant addition to NTWIST's portfolio of technical capabilities as a result of this project is automatic identification of most relevant feature extraction. The large number of features and the complexity of the lighting conditions made it necessary to reduce reliance on manual feature engineering. This work will greatly increase the speed of identifying features in future projects.

On the modelling side, NTWIST gained experience and produced re-usable code for ensemble models. In addition to expanding the code inventory, NTWIST's machine learning specialists now have a better understanding of formulating process control objectives mathematically.

Finally, NTWIST gained experience in opportunity/value identification which will now become a new marketable service designed to appeal to customers in mining who are interested in leveraging AI but are not certain how/ whether AI can be applied to improve their operation.

Please provide a narrative outlining the project's outcomes. Please use sub-headings as appropriate.

- **Project Outcomes and Impacts:** Describe how the outcomes of the project have impacted the technology or knowledge gap identified.
- **Clean Energy Metrics:** Describe how the project outcomes impact the Clean Energy Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Program Specific Metrics:** Describe how the project outcomes impact the Program Metrics as described in the *Work Plan, Budget and Metrics* workbook. Discuss any changes or updates to these metrics and the driving forces behind the change. Include any mitigation strategies that might be needed if the changes result in negative impacts.
- **Project Outputs:** List of all obtained patents, published books, journal articles, conference presentations, student theses, etc., based on work conducted during the project. As appropriate, include attachments.

RESPOND BELOW

G. OUTCOMES AND IMPACTS

The outputs of the computer vision modules will be operationalized using NTWIST's software platform. The platform has the necessary back-end infrastructure to communicate with the plant's existing control room software and video network, and a front-end user interface which can display information to control room operators, as a separate user interface. The software package delivered have several key features:

- “Soft sensors” which display key metrics extracted from the video feed in real time. For example, one of the soft sensors is displaying the value of the ore grade to control room operators. This information is determined by the computer vision modules from the video feed.

- Alarms which alert the operator if any actions are necessary based on the values of any of the metrics measured by the soft sensors. For example, alerting the operator if more water addition is necessary to maintain the proper slurry concentration at the ore processing plant based on the current ore grade.

- Recommendations which are provided to operators on which actions to take to achieve optimal outcomes. For example, recommending a specific setpoint for water addition to the ore slurry achieve optimal bitumen extraction downstream.

Collectively the software delivered is helping with:

- Standardize the interpretation of remote visual video feeds to the control room

- Reduce the burden on operators by providing them with alarms and recommendations when needed

- Allow for tighter control of key operating parameters

- Improve bitumen extraction efficiency

- Decrease GHG emissions

- Reduce water consumption

The NTWIST software development has four main deliverables:

- A computer vision module to detect the ore grade at the ore processing plant. This module will be used to determine water addition necessary to meet the desired density profile with an accuracy of ~80% or above.

- A computer vision module to detect the level of the froth/middlings interface at primary separation unit. This module should detect the level with an accuracy of 95% or higher under any plant conditions including lighting variations, partially obstructed view, poor camera feeds, etc..

- Develop a continuous learning algorithm that will allow the above modules to adapt to changing process conditions over extended periods aiming for the right-first-time (RFT) mode of process 95% of the time.

- Leverage NTWIST’s existing software platform to communicate with existing control room automation systems for tighter control and make recommendations to the control room operators. This includes developing a software architecture that is efficient in dealing with massive video data and a vendor agnostic archive strategy that can be integrated with any DCS product.

Please provide a narrative outline the project's benefits. Please use the subheadings of Economic, Environmental, Social and Building Innovation Capacity.

- **Economic:** Describe the project's economic benefits such as job creation, sales, improved efficiencies, development of new commercial opportunities or economic sectors, attraction of new investment, and increased exports.
- **Environmental:** Describe the project's contribution to reducing GHG emissions (direct or indirect) and improving environmental systems (atmospheric, terrestrial, aquatic, biotic, etc.) compared to the industry benchmark. Discuss benefits, impacts and/or trade-offs.
- **Social:** Describe the project's social benefits such as augmentation of recreational value, safeguarded investments, strengthened stakeholder involvement, and entrepreneurship opportunities of value for the province.
- **Building Innovation Capacity:** Describe the project's contribution to the training of highly qualified and skilled personnel (HQSP) in Alberta, their retention, and the attraction of HQSP from outside the province. Discuss the research infrastructure used or developed to complete the project.

RESPOND BELOW

H. BENEFITS

NTWIST's solution automates the monitoring of remote visual feeds which would normally require a significant amount of their attention. This helps to reduce the information overload which these operators are often faced with and allows them to focus on other more important aspects of their job. The alerts and recommendations provided by NTWIST's platform further reduce their workload by providing data driven guidance on which actions to take and when.

The paying customers for the solution are the oil sands companies processing raw ores into bitumen. These companies benefit financially from the tighter operational control which is enabled by the quantification and standardization of the ore grade assessment and froth/middlings level detection. Improvements in the efficiency of bitumen extraction reduce bitumen content in tailings and are expected to lead to millions of dollars in additional revenue each year, while the reduction in energy and water consumption provide cost reduction and GHG emission reduction benefits.

Using approximately 30 days of laboratory data (one week of camera control, two weeks of Capacitance probe control), it has been calculated that the Bitumen losses in Tailings dropped by 53.6%. A similar reduction of 29.12% has also been noticed in Bitumen losses to Middlings. The laboratory data indicate increased economic benefit and reduced environmental losses. Process data collected for the same duration also indicated significant reduction in the variance of process variables around the separation cell (Interface level, Tailings pump speed, Tailings

flow rate, Froth temperature, etc.) resulting in a steadier process operation benefiting the downstream processes.

Please provide a narrative outlining the next steps and recommendations for further development of the technology developed or knowledge generated from this project. If appropriate, include a description of potential follow-up projects. Please consider the following in the narrative:

- Describe the long-term plan for commercialization of the technology developed or implementation of the knowledge generated.
- Based on the project learnings, describe the related actions to be undertaken over the next two years to continue advancing the innovation.
- Describe the potential partnerships being developed to advance the development and learnings from this project.

RESPOND BELOW

I. RECOMMENDATIONS AND NEXT STEPS

Following the 3 months of production testing, we will continue collect the performance statistics from plant and utilize live video feed to refine the machine learning algorithms as needed. In parallel we will focus on the commercializing the software into other oil sands operations.

The proposed solution is directly relevant for operators of open pit oil sands mines. NTWIST will be focusing on the seven Albertan operations that fall into this category. Collectively these operations produced an average of 1.61 Million barrels per day in 2019. A typical primary separation unit has a capacity of 75,000 barrels/day indicating there are approximately 21 primary separation units active in Alberta. Each operation will have a single ore processing plant where ore characterization occurs. Strategically, this beachhead market serves to establish credibility and basic software functionality for the markets described above.

J. KNOWLEDGE DISSEMINATION

Please provide a narrative outlining how the knowledge gained from the project was or will be disseminated and the impact it may have on the industry.

RESPOND BELOW

AI Adoption

According to Alberta Innovates' 2018-2019 annual report, the province invested $278 million on research and innovation in 2018 to achieve impact in Alberta and beyond. Two of the three strategic priorities are to enhance Alberta's knowledge workforce to modernize its economy, and apply emerging technologies such as artificial intelligence across industry sectors.

According to McKinsey (McKinsey & Company, 2018) countries that lead in the adoption of AI technology could capture an additional 20 to 25 percent in net economic benefits, compared with today. Canada's economic future will be shaped by adoption of AI, and it's absolutely critical to increase domestic capabilities in this field. This project will help in creating a link between AI research and industrial adoption of AI in Alberta.

Widespread adoption of AI technology by Alberta resource industries could see a shift in job demands in the province away from repetitive tasks toward those that are socially and cognitively driven and require more digital skills. This is important for Alberta companies to remain competitive globally.

K. CONCLUSIONS

Please provide a narrative outlining the project conclusions.

- Ensure this summarizes the project objective, key components, results, learnings, outcomes, benefits and next steps.

RESPOND BELOW

The main objective of this project is that control room operators are provided with the data they need in real time in order to maximize the bitumen extraction and minimize operating costs for the ore processing and extraction stages of oil sands operations. This objective will also serve NTWIST's strategic objective of integrating advanced video analytics into its product offering.

The deliverables above will allow for a significant reduction in water, power and chemical consumption in the ore processing and extraction stages, leading to significant GHG emission reductions. We estimate the size of the opportunity for companies like Suncor will save approximately $23.8M /year, by applying the solution across their operation due to improved bitumen extraction efficiency and save approximately $190,000 per year from reduced hot water usage. The NTWIST commercial activity will also immediately create 3 jobs for future sales, project support and strengthen Alberta's position as a leader in applied artificial intelligence.

Artificial Intelligence Assisted Computer Vision Application in Oil & Gas Mining Industry

Alberta Innovates File # 202101886

Public Final Report

Submitted on: October 30, 2022

Prepared for
Alberta Innovates, Claude Ghazar

Prepared by
NTWIST Inc

Chowdary Meenavilli, CEO

Phone# 780-807-4023, email: cmeenavilli@ntwist.com