University of Victoria
Engineering & Computer Science Co-op
Work Term Report
Term (Summer) 2022

Integration of AI into Civil Engineering

Herold Engineering Limited
Civil Department
Nanaimo, B.C., Canada

Ben Roberts
V00974976
Work Term 1
Mechanical Engineering
benjaminr@uvic.ca
August 26, 2022

In partial fulfillment of the academic requirements of this co-op term

Supervisor's Approval: To be completed by Co-op Employer

This report will be handled by UVic Co-op staff and will be read by one assigned report marker who may be a co-op staff member within the Engineering and Computer Science Co-operative Education Program, or a UVic faculty member or teaching assistant. The report will be retained and available to the student or, subject to the student's right to appeal a grade, held for one year after which it will be deleted.

I approve the release of this report to the University of Victoria for evaluation purposes only.

Signature: _____ Position: _____ Date: _____

Name (print): _____ E-Mail: _____

For (Herold Engineering Limited) _____

Ben Roberts
University of Victoria
Victoria, B.C.
V8P 5C2

August 26th, 2022

Susan Fiddler, Coop Coordinator
University of Victoria
Victoria, B.C.
V8P 5C2

Dear Mrs. Fiddler,

Please find attached the Work Term Report titled “Integration of AI technology into Civil Engineering.”

The resulting report is from my time at Herold Engineering Limited (HEL). This is my first work term done with the University of Victoria and it was with the civil consulting group at Herold Engineering. I was a part of many projects assisting with data collection, base plans, surveys, and tender documents. Throughout this work, I realized there were some repeatable tasks that were not very efficient on time at all. This led me to the idea of incorporating Artificial Intelligence and Machine Learning into HEL and its civil department. That Idea is what the subject of the report is.

During the work term, I was given many opportunities to develop and grow my understanding of what engineering actually is in the workplace. I did this through learning CAD skills, surveying, and other things. These skills and understanding I believe will be very beneficial to me in future work terms and jobs.

Again, I would like to thank my manager, Patrick Ryan, for his dedication to my understanding of what it truly means to be an engineer and the other workers for assisting me with things I did not understand providing me opportunities to see projects they were working on.

Sincerely,

Ben Roberts

TABLE OF CONTENTS

LIST OF FIGURES…….…..v

1. EXECUTIVE SUMMARY……..vi

1.1 OVERVIEW……..……..……..vi

1.2 SOLUTION SUMMARY……vi

1.3 TECHNICAL/MARKET ANALYSIS…….vi

1.4 RECOMENDATIONS...…….....vi

2. INTRODUCTION…….…....1

2.1 BACKGROUND……...2

2.2 OBJECTIVE……..…2

3. CURRENT SOLUTION…….…...2

4. SOLUTION ONE……...…….…...2

4.1 HOW WOULD AI HELP……..2

4.2 TECHNICAL ABILITY OUTLINE….…….....3

4.3 AVAILABLE TECHNOLOGY…….…….……..6

4.4 MARKET/TECHNOLOGICAL FEASABLITY…….....6

5. SOLUTION TWO…...……..…8

5.1 TECHNICAL ABILITY OUTLINE……...……...8

5.2 EXCISTING TECHNOLOGY……..……9

5.3 MARKET/TECHNOLOGICAL FEASABLITY……....10

6. CONCLUSION……..……11

6.1 CONCLUSION……..……..11

6.2 RECOMMENDATIONS…….12

REFERENCES…….13

LIST OF FIGURES

1. Nanaimo Map Utility layer…….…….……..……..4
2. City of Nanaimo Asbuilt Download……...…….5
    a) Selection Process……..……...5
    b) Download Screen…….……5
3. AI Market Growth Prediction……..……....7
4. HEL Water Utility Map of Nanaimo…..…….……9
5. CAD Water Pipe Details Library……..……...……9

1. EXECUTIVE SUMMARY

1.1 PROBLEM:

Once a new project is awarded Herold Engineering Limited (HEL) must do background research on the site and its utilities. This process is very exaggerated and time-consuming due to the reorganization of documents and municipalities. This is a problem because lately lots of projects have had to re scope or go on hold due to bid prices being so high due to the current market. If this simple and repetitive task were to be done by a more efficient means it could be the difference needed.

1.2 SOLUTION SUMMARY:

The First solution to the problem that was presented is a small-scale integration of Artificial Intelligence (AI) into HEL. During the research, it was found that there are multiple existing services that can be used for exactly what HEL would need and more. The second solution is a larger-scale integration. It would incorporate all of solution one and aid in CAD drawings and base plans. It would do this through a list of restraints, be it cost or material, and then give possible solutions.

1.3 TECHNICAL/MARKET ANALYSIS:

Currently, the market for these solutions is increasingly growing and available. The first solution at this moment appears more feasible and realistic but, solution two is also available however at a less attainable level. The technology exists for both of these solutions but the first solution is more widely available with multiple options for providers.

1.4 RECOMMENDATIONS:

The key next step to our design is further cost analysis and meeting with technicians for the AI companies about how realistic and attainable these would be. The solution that would be recommended would be the first and then further down the road when AI in CAD develops more that area can be developed into.

2. INTRODUCTION

2.1 BACKGROUND

The client in this situation is Herold Engineering Limited (HEL) a Civil and Structural engineering firm based out of Nanaimo with clients covering Vancouver Island. HEL has been involved in Civil engineering since 2000 [1]. Currently, there is a lot of work required to gather information about sites for each project. In this report, it will be discussed how this problem can be dealt with by examining the current procedure which is followed then the solution of the integration of Artificial intelligence (AI) at a small and larger scale. Integrating AI would reduce the amount of time the EITs and PEngs have to spend on projects allowing for both the client and HEL to save money on services. With the current market, lots of bids for projects have been way over budget resulting in re-scoping of projects or the cancellation of them. If a solution were put into place it could result in more jobs being completed at lesser costs. Currently, at HEL the process of gathering Utilities is exacerbated due to municipalities not all using one centralized website to store utility information and as build data. In the report, the current procedure will be covered as well as a small-scale solution and a larger-scale solution. In the small-scale solution, AI will be used to aid in the leg work of a project. It will be used to gather as builds, do BC1 calls, etc. In the larger scale solution, it will aid in Computer-Aided Design (CAD) to design base plans and implement pre-exciting details to create designs off of restraints made by an engineer.

2.2 OBJECTIVE

The issue at hand is the process of gathering information. This process is time-heavy which costs clients a lot for very basic and repetitive work. This is due to municipalities using different formats and there is not one way to find asbuilts. Some municipalities even have multiple websites or GIS maps to get the information required for a project/site. Therefore, the goal of the report is to find a solution to this problem that allows for the conservation of time. If a solution were to be found that would be able to gather the utility and asbuilt information in a more time-effective matter it could be implemented. At a more complex stage, a solution with the capability to not just help with the research of sites but the design process in CAD would be ideal. The constraints of this report are the cost analysis and comparison of products. However, the feasibility of each solution will be discussed at the end of each solution.

3. CURRENT SOLUTION

The way this problem is currently being handled is through research. Is by searching through the HEL server or the web. Although this may not seem like a problem the HEL servers do not hold all asbuilts and or site information and even then you still need a way to find relevant asbuilt numbers. If this process still does not result in enough information one would then begin to contact the client or someone with the city/municipality to try and find more information. Another thing that must be done is BC1 calls which expand more time and further decentralizes the process of gathering information.

4. SOLUTION ONE

4.1 HOW WOULD AI HELP

Why would we use AI? AI has the ability to use Machine Learning (ML), deep learning, cognitive computing, and computer vision [2]. Machine learning allows AI to increase its

efficiency and knowledge over time as well which would mean that the efficiency as the AI is put more and more to work would increase allowing for an increasingly efficient process [2]. AI is still a relatively new technology and is constantly being developed however machine learning is nothing new to Civil engineering and has been around since complex skyscrapers started to be designed [3]. Also in [3], it is explained how AI is being used for facility management, more specifically it shows all relevant data about a site and gives recommendations. In [4] it is stated that using AI to enhance business operations is vital, it can be extremely useful when doing repetitive formulaic tasks. Since gathering asbuilts and utility information and noting what it is a formulaic process AI would be selected as a perfect option to help improve the current procedure.

4.2 TECHNICAL ABILITY OUTLINE

The software that would need to be used must have the ability to locate certain locations on a map and turn certain things on such as the utilities in figure 1 [5]. To do this the AI would have to be able to go on municipality websites and find GIS maps. It would also have to be able to find relevant asbuilt numbers store those then use HEL servers to find those corresponding documents or be able to just download the applicable asbuilts directly from the municipality's page if available. To do this there must be a list of restraints and or addresses are given to allow the AI to withdraw as much information and then filter it to what is relevant to civil works. Ideally, the AI would allow one to select an area of interest on a GIS map and be able to get that area's address, and find all the materials previously stated. The system in place by CoN for downloading asbuilts is quite effective and if the AI's functions could model similar to it that would be ideal. Figures 2,3 shows how the CoN asbuilt downloader works, one selects an area and then the asbuilts related to that location are available for download below. The one downside

to this system is that the asbuilts downloaded are not always relevant. If the system to be used could then sift through and determine what is relevant that would be ideal.

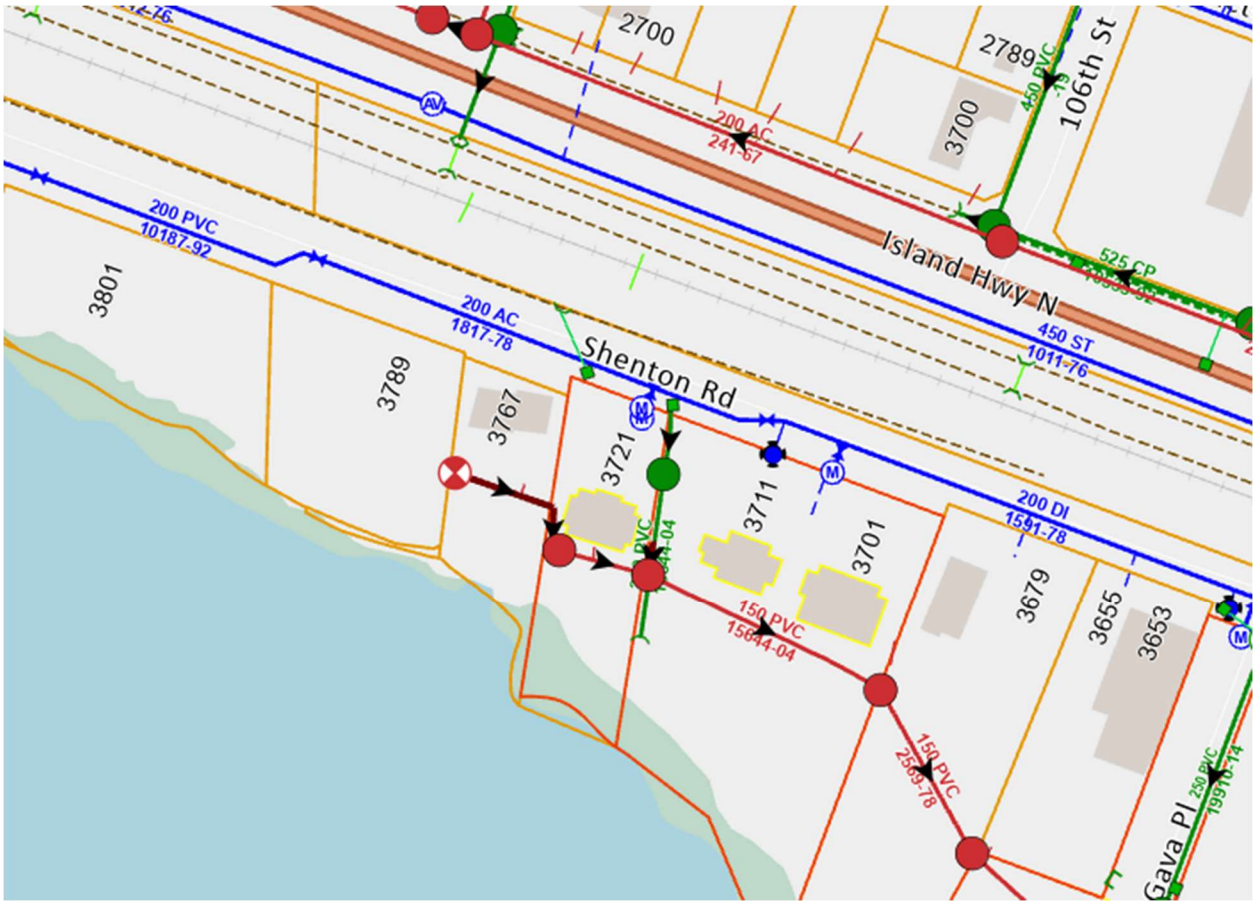

Figure 1: Nanaimo Map Utility layer of HEL Office

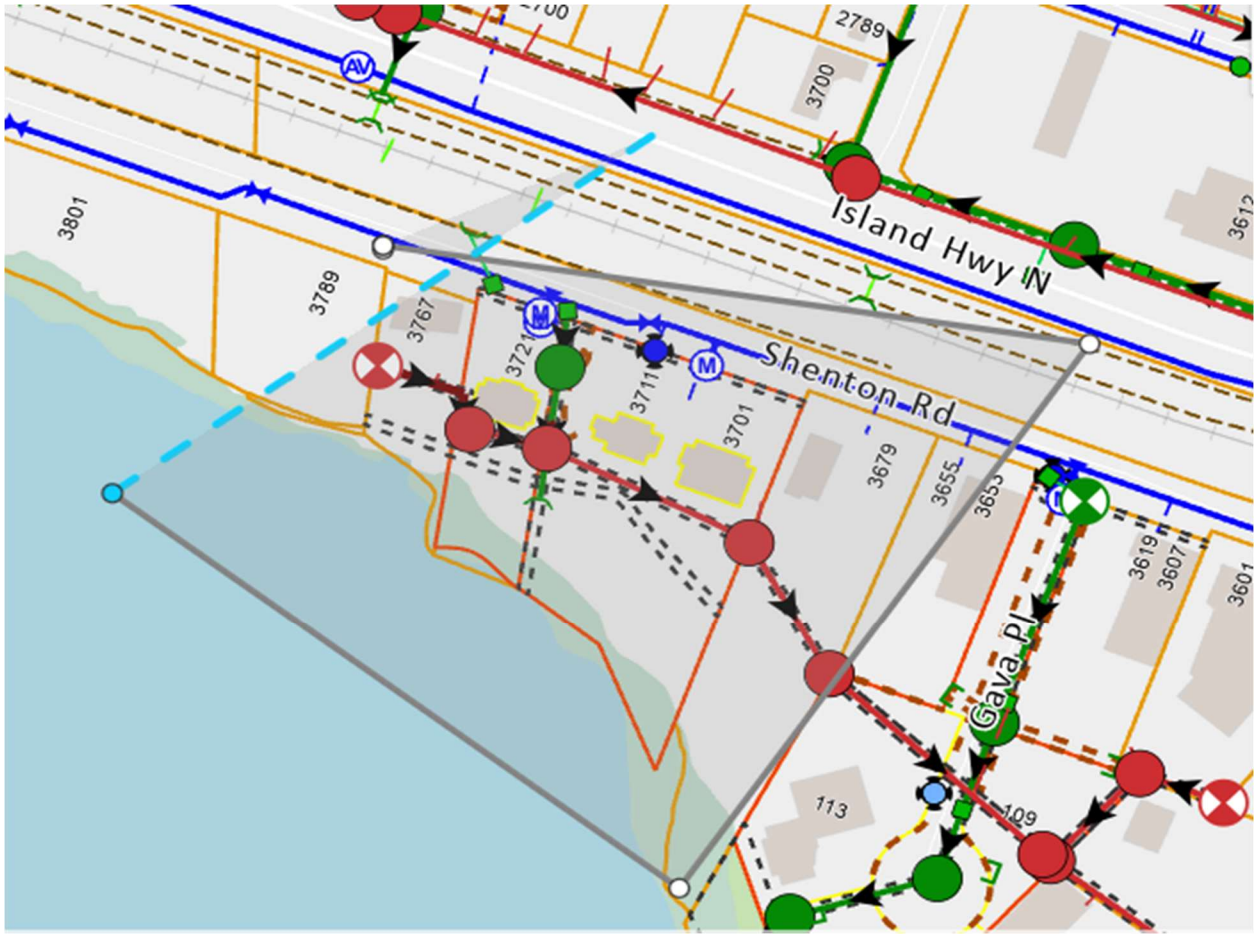

Figure 2.a: Selection Process

	Drawing Number	Drawing Title
☑	1009	PLAN & PROFILE ISLAND HIGHWAY
☑	1010	PLAN & PROFILE ISLAND HIGHWAY
☑	1011	PLAN & PROFILE ISLAND HIGHWAY
☑	1012	PLAN & PROFILE ISLAND HIGHWAY
☑	1013	PLAN & PROFILE ISLAND HIGHWAY
☑	1014	PLAN & PROFILE ISLAND HIGHWAY
☑	1104	DOMESTIC WATER SYSTEM
☑	1591	8" DI WATER MAIN
☑	1721	SHENTON ROAD
☑	1817	8" AC WATER MAIN
☑	2534	SITE PLAN
☑	2535	KEY PLAN
☑	2536	DRAWING INDEX KEY PLAN
☑	2537	PLAN & PROFILE FROM SMH NO 27 (EXISTING 24" TRUNK) TO MH 3
☑	2538	PLAN & PROFILE - FROM MH3 TO MH14 (AT EAST WELLINGTON ROAD)
☑	2539	PLAN & PROFILE - FROM MH 3 TO MH 7 (AT HANSEN ROAD)
☑	2541	PLAN & PROFILE - MADSEN & GRIFFITHS RDS FROM SCO 5 TO MH 14

Figure 2.b: Download Screen

4.3 AVAILABLE TECHNOLOGY

Now that we have an understanding of what we need it is important to review existing technology to see if any aligns. Through research, I deemed the Oxylabs Next-Gen Residential Proxies to be a good candidate for the job [5]. It has a 100% success rate on tasks given to it. It does this through repeated repetition on it (Auto-Retry system). It is designed for business application and research. The technology is currently fully available for the right price. Urbint Lens for Damage Prevention is currently a technology primarily used in New York City that is used as a before-you-dig utility location. It uses user-supplied location and reports back with all important data including surrounding objects, soil conditions, weather, population density, construction, age, type, and location [6]. [6] also has immense data that it uses to provide users with more information as well as gives past tickets people have gotten and what they did [6]. With all this information they reduced the utility damage/destruction by 37% from 2016-2020. This technology is also another prime candidate for HEL to implement due to its primary function being a utility information gatherer and reporter. Currently, Urbint is only an electrical, gas, and communication/cable locator but they have plans to expand into the other utility in the future [6]. Although the technology is very prevalent and available for purchase the most important part is that a small-scale implementation of AI actually makes sense for HEL.

4.4 MARKET/TECHNOLOGY FEASABLITY

The feasibility of AI in the HEL offices can be broken down further into the technical feasibility and market feasibility. For the technical feasibility, this would have to be further discussed with the IT department. But for integration into the existing infrastructure, it should be of little difficulty; most AI is compatible with existing code and HEL uses JavaScript [5]. Therefore it can be determined with some more research how feasible the technology is for HEL integration

since it already is widely available for purchase. Though more research still remains to be done, that will be the next steps/recommendations. For the market feasibility, it will only increase in the next 10 years. Currently, the AI market size is valued at 93.5 billion USD and is projected to have an annual compound growth of about 38% from 2022-2030 [7]. This is due to the expected advancements and general growth as this technology becomes increasingly accessible to the public [7]. Figure 4 shows the projected growth, and that the majority of AI will be in services which is the market that HEL would need anyways. In [8] it discusses the market of construction which is estimated to be a 10 trillion dollar field and how AI is being heavily invested in construction services specifically Civil engineering. It will aid with analysis and the compilation of other things [8] states. Since the market seems to be ever-expanding it can be determined that AI is very feasible technically and markedly.

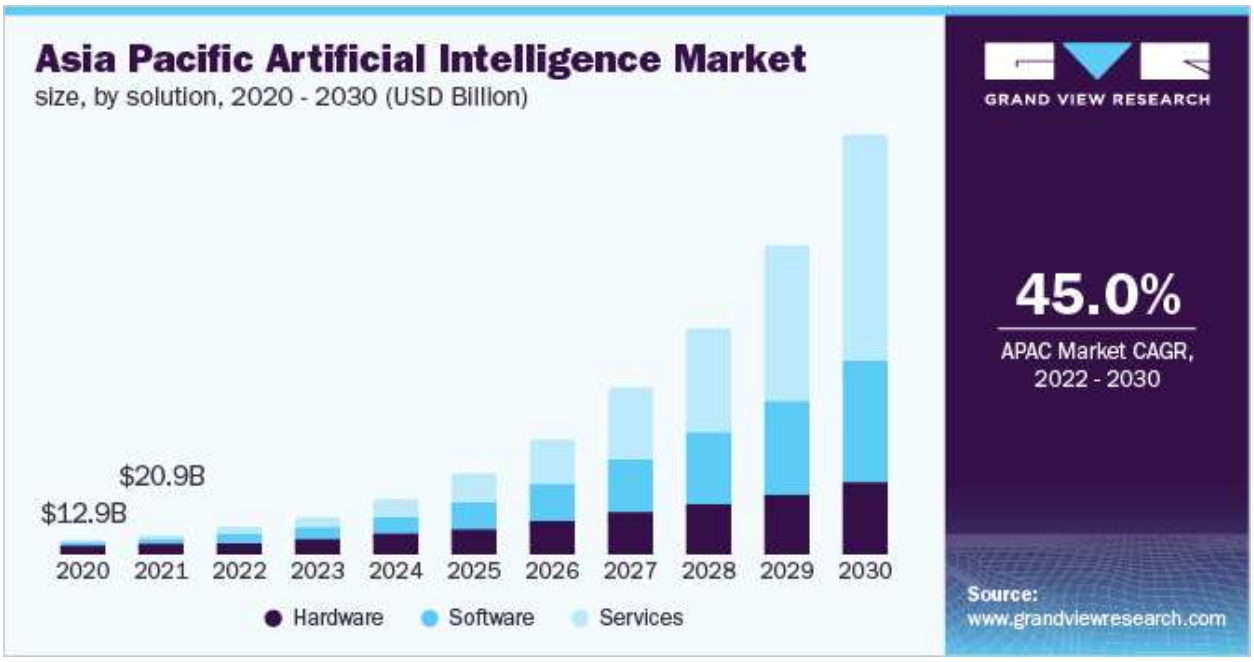

Figure 3: AI Market Growth Prediction

5. SOLUTION TWO

5.1 TECHNICAL ABILITY OUTLINE

For the second solution or the larger scale AI integration it would incorporate all the same features as stated in solutions one and more. For the larger scale integration, we would have the AI aid and potentially complete civil drawings and or base plans in CAD. The information the AI gathers can then be converted to a base plan using existing HEL data. At HEL there are existing Auto CAD maps of the CoN for water, sanitary, cadaster, and storm in the UTM coordinate system (see figure 5) [1]. If given a location the AI should be able to compile a base plan using all this data for the CoN projects. For projects existing in different municipalities, it becomes more difficult, and depending if there is an existing CAD or not an engineer may be required to do that aspect. Another thing the AI should do is be able to give recommendations for pipe systems based on a list of restraints. There is also a file of CAD details of approved products for Vancouver Island made at a 1:1 scale that the AI could use to incorporate into recommendations and analysis of projects (see figure 6). For the Ai to be able to do all this it must be determined what the current state of technology is for the civil engineering field.

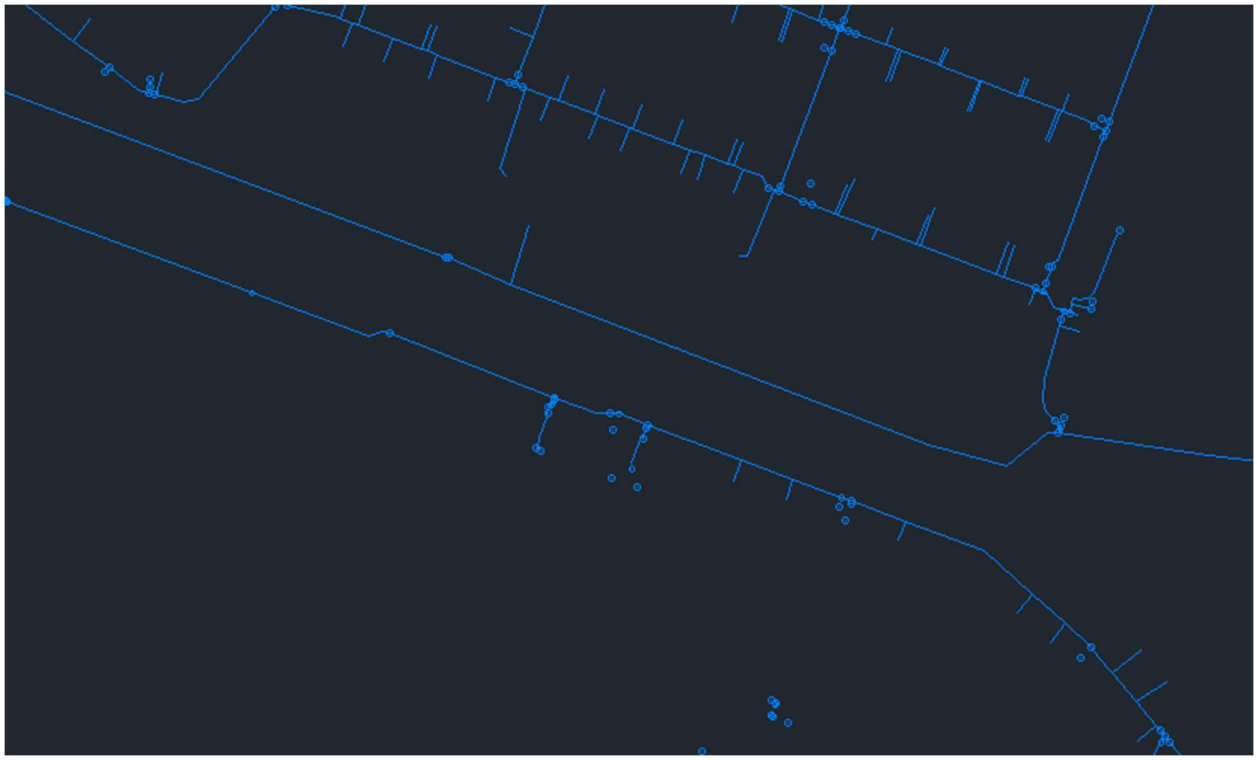

Figure 4: HEL CAD Water Utility Map of Nanaimo

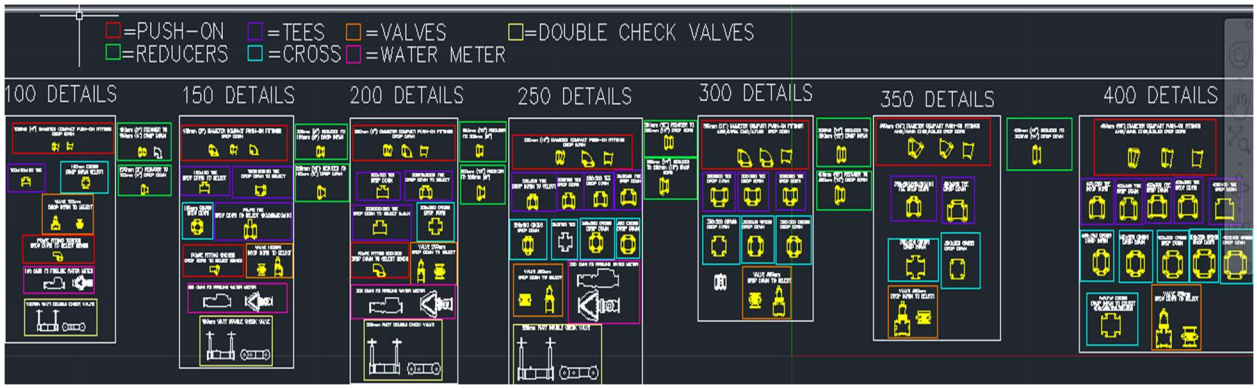

Figure 5: CAD Water Pipe Details Library

5.2 EXCISTING TECHNOLOGY

Currently the technology exists for AI to assist in AutoCAD. In [3] they discuss how AI can assist in construction solutions and help with design optimization, parameter estimations, and

identification. [3] also goes on to say that the damage detection in civil engineering is highly digitized which is where the future developments of AI in civil engineering will assist. Automation of pipe designs is also something that has begun to become more prevenient. [9] examines the development of the optimization of pipe designs in ships. They talk about how the process of designing pipe systems is a very man-hour-heavy task and with the aid of AI it makes the process extremely efficient and also optimized [9]. This technology as it continues to develop would align with exactly what civil engineers need [9]. Users would be able to significantly reduce the initial stages of pipe routing design and reduce the overall design lead time. Specifically, in CAD AI and ML are already being used for simple processes such as analyzing statistics and others and giving recommendations [10]. As AutoCAD continues to develop its AI technology it will address problems such as: speeding up the drafting process by generating options based on criteria such as weight or cost, automatically updating designs to fit appearance or performance criteria, and suggestions based on past projects worked on and continuing to develop the AutoCAD program and its AI based on concurrent feedback [10]. Autodesk has plans to release a more powerful AI with more specifically ML in the updated version in 2023 that will help reduce repetitive tasks and gain higher competency levels [11].

5.3 MARKET/TECHNOLOGICAL FEASABLITY

The feasibility of solution 2 can be broken down into two groups one is the market feasibility and the other the technological feasibility. The market currently for solution two is slim but with the upcoming release of AutoCAD 2023, the market should only increase. Based on figure 4 you can see that the market for all AI products should steadily increase. However, there currently is a product called Project Assist for AutoCAD Civil 3D [12]. Project Assist can assume your design is based on an existing ground surface and provide a forum for review and editing, provides road

templates, adds curb ties directly to connecting roads, and automatically designs more complex areas including tuning lanes, widenings, cul de sacs and islands [12]. However, the technology still has some improvements. Currently, it is still in a developing phase, but Autodesk has plans to incorporate more AI into the newest AutoCAD in 2023 which will greatly develop the amount of AI involved [11]. Therefore, for the current technology involved in solution two, it can be determined that solution two is feasible in 2-3 years from now when the technology is better developed and has more time to be tested.

6. CONCLUSION

6.1 CONCLUSION

Herold Engineering Limited (HEL) is a civil engineering firm located on Vancouver Island with clients spanning the island and more. Currently, when they get new projects and jobs there is an excessive amount of work required to get information about the site and utilities due to not all municipalities having a solid system in place. To solve this problem I presented two solutions, one being a small-scale implementation of Artificial Intelligence (AI) and Machine Learning (ML) to aid in the process of gathering utility and site information as well as managing that information. It was found that there are multiple programs currently available that could be implemented into HEL, one being a utility locator and before you dig AI primarily used in New York has been extremely effective [6]. This solution is very practical with the current state of AI in civil engineering. The larger scale solution implemented the same aspects as solution 1 but also would aid engineers in the development of base plans and designs. Currently, the technology is available but not widely. The Ai and ML can help with recommendations for the design and optimization of pipe systems as well as complete repetitive tasks for you. Since the technology is

not widely available it does not currently make sense to incorporate the large-scale solution into the HELs system as of current. Because of this, my recommendation would be to implement solution one after further and deeper research then once more research and technology have been created for aiding in CAD then implement the larger scale solution.

6.2 RECOMMENDATIONS

For these solutions to be implemented my recommendations would be for further research into the different options. I would also recommend a consultation with IT at HEL to discuss what work would need to be done for either solution to be implemented in the office. Some specific areas of research would be compatibility, functionality, and cost. A proper cost analysis should also be conducted comparing the cost of having an engineer do the work versus the costs for AI. There should also be discussions with municipalities to discuss if this technology can be implemented to see if they are ok with AI gathering the information on behalf of someone else.

CITED REFERENCES

[1] Herold Engineering Limited, "About Us," *Herold Engineering Limited*, 02-Oct-2020. [Online]. Available: https://www.heroldengineering.com/about-us/. [Accessed: 19-Aug-2022].

[2] Western Governors University, "What is AI technology and how is it used?," *Western Governors University*, 31-Mar-2020. [Online]. Available: https://www.wgu.edu/blog/what-ai-technology-how-used2003.html#close. [Accessed: 19-Aug-2022].

[3] S. Gullion, "Uses of Artificial Intelligence in civil engineering," *Keck & Wood Civil Engineers, Duluth, Fayetteville GA, Rock Hill, North Charleston SC*, 05-Jun-2020. [Online]. Available: https://keckwood.com/news-updates/uses-of-artificial-intelligence-in-civil-engineering/. [Accessed: 19-Aug-2022].

[4] M. TARAFDAR, C. BEATH, and J. ROSS, "Using AI to enhance business operations," *How AI Is Transforming the Organization*, 2020.

[5] "Ai web scraping with next-gen residential proxies," *Oxylabs*. [Online]. Available: https://oxylabs.io/products/next-gen-residential-proxies. [Accessed: 19-Aug-2022].

[6] "How gas utilities use Artificial Intelligence Technology for damage prevention," *How Gas Utilities Use Artificial Intelligence Technology for Damage Prevention*. [Online]. Available: https://www.urbint.com/blog/gas-utilities-artificial-intelligence-damage-prevention. [Accessed: 19-Aug-2022].

[7] *Artificial Intelligence Market Size Report, 2022-2030*. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-market. [Accessed: 19-Aug-2022].

[8] A. Zharovskikh, "Ai in Civil Engineering: Use Cases and benefits," *InData Labs*, 20-Apr-2022. [Online]. Available: https://indatalabs.com/blog/ai-in-civil-engineering. [Accessed: 19-Aug-2022].

[9] S.-H. Kim, W.-S. Ruy, and B. S. Jang, "The development of a practical pipe auto-routing system in a shipbuilding CAD environment using network optimization," *International Journal of Naval Architecture and Ocean Engineering*, 16-Mar-2016. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2092678216303284. [Accessed: 19-Aug-2022].

[10] "Relevance of AI in Computer-Aided Design," *Software Delivery Simulator*, 05-Jul-2022. [Online]. Available: https://softwaresim.com/blog/relevance-of-ai-in-computer-aided-

design/#:~:text=AI%20is%20often%20embedded%20within,improving%20the%20decision%2Dmaking%20process. [Accessed: 19-Aug-2022].

[11] A. Frausto-Robledo, “Autodesk Autocad 2023 - ai, upskilling users and performance,” *Architosh*, 26-May-2022. [Online]. Available: https://architosh.com/2022/05/autodesk-autocad-2023-ai-upskilling-users-and-performance/#:~:text=Artificial%20intelligence%20(AI)%20continues%20to,competency%20levels%20in%20AutoCAD%20itself. [Accessed: 19-Aug-2022].

[12] ZenTek Consultants, “A.I. for civil 3D: Design a subdivision in minutes: Zentek,” *ZenTek Consultants*, 31-Mar-2022. [Online]. Available: https://zentekconsultants.net/a-i-for-civil-3d-design-a-subdivision-in-minutes/. [Accessed: 19-Aug-2022].

GENERAL REFERENCES

City of Nanimo, *Online Services*. [Online]. Available: https://www.nanaimo.ca/city-services/online-services. [Accessed: 19-Aug-2022].