Engineering Portfolio

Cooper Cole
University of Waterloo, Candidate for BASc - Mechatronics Engineering, 2024

Fall 2022

Table of Contents

Steel Billet Exchange Assembly

April 2022

The objective of this project was to design a table for pallets of steel billets to be exchanged with an automation robot cell on a manufacturing line; the table must interface with pre-existing pallet carts and pallets and meet ANSI/ISO safety standards for manufacturing lines. From this objective, the table was designed around the dimensional constraints of the pre-existing pallet carts and part pallets.

The precision welding and large-scale machining required to meet the dimensional constraints set by the pallet carts was not available. Thus, the greatest challenge was designing the assembly with parts that can be easily fabricated by the in-house machinists, while staying within the dimensional constraints and avoiding tolerance stack up. This was overcome by using datum pins to ensure position repeatability and adding adjustability to position critical parts using slot holes.

The assembly contains over 50 unique commercial parts and 40 unique custom parts designed in SolidWorks. The design is easily fabricated with stock dimensioned materials and meets ANSI/ISO safety standards for automated manufacturing lines The final design achieves the objective and meets the constraints and criteria and outlined in the objective statement. See Figure 1 to Figure 5 for visuals.

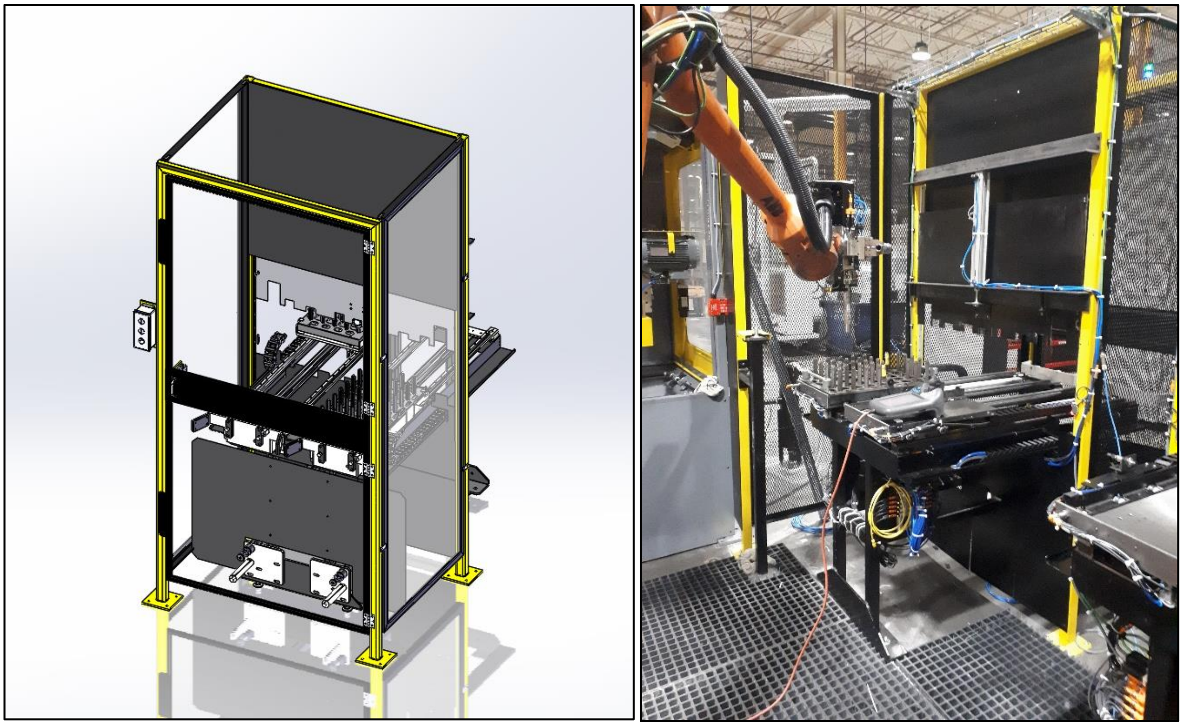

Figure 1: Steel Billet Exchange Assembly

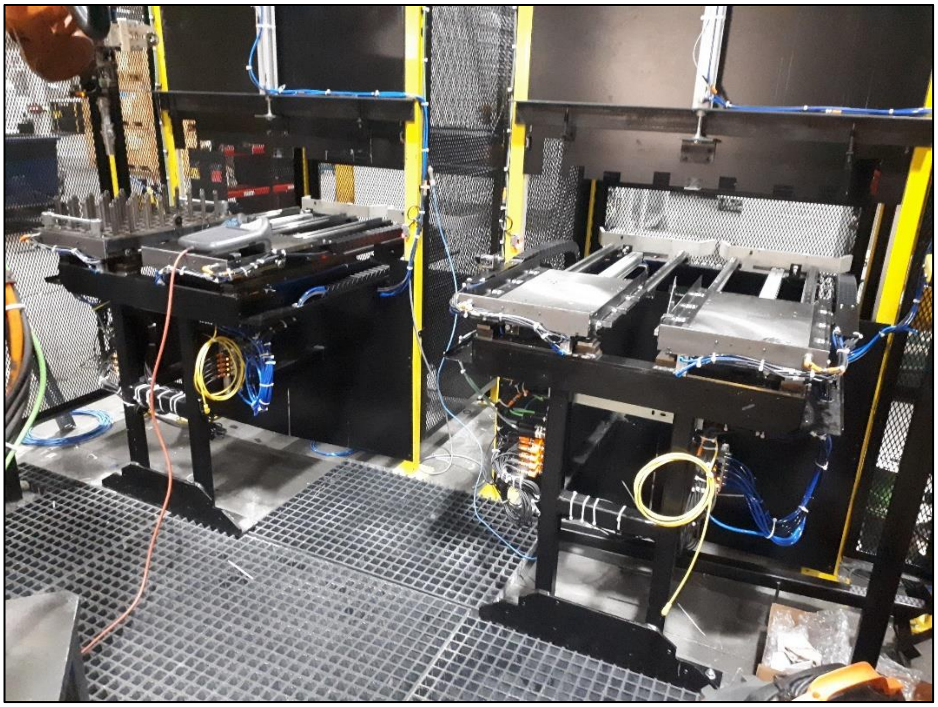

Figure 2: Steel Billet Exchange Assembly Rear View

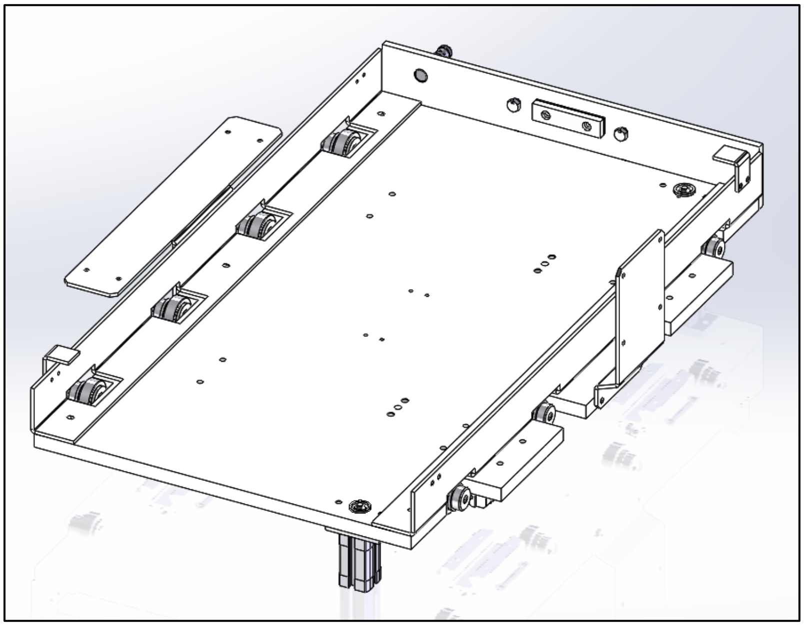

Figure 3: Pallet Dolly

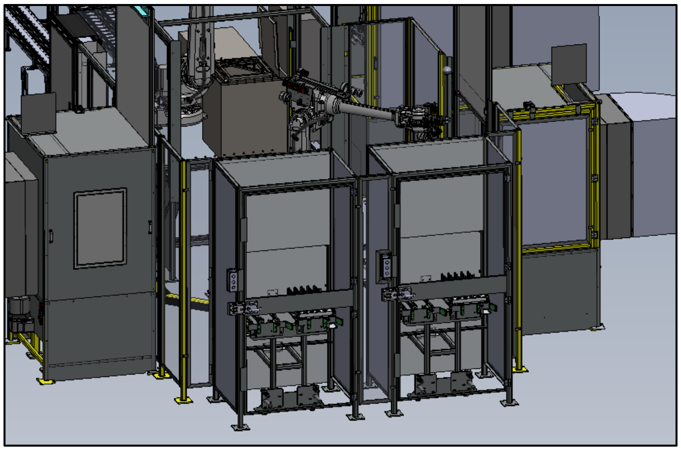

Figure 4: Automation Cell Model

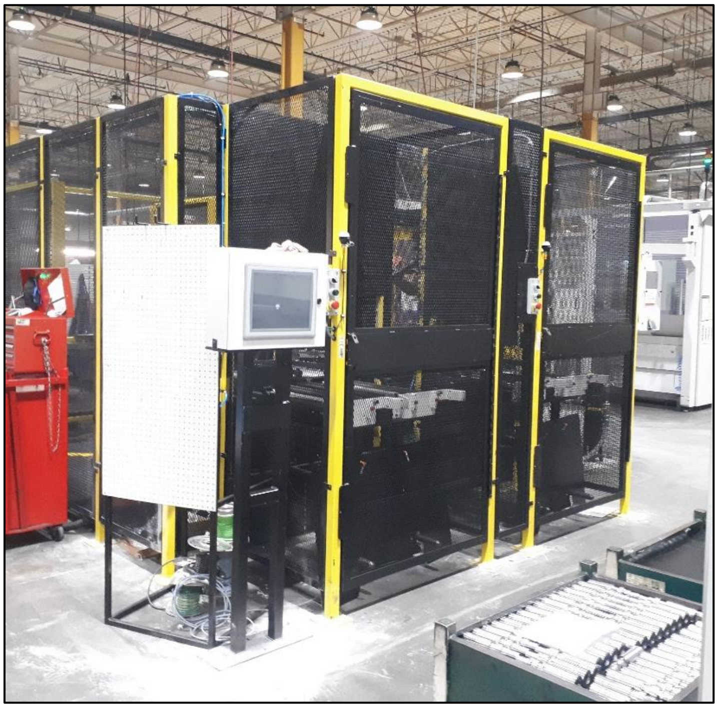

Figure 5: Automation Cell Front View

Robot Cell Part Reject Nest

January 2022

Redesigned the factory's standard robot cell part nest using SolidWorks to improve manufacturability, cut material cost and reduce assembly time by 50%. Purchased the necessary sensors, assembled the nest, and programmed the robots automated manufacturing routine to use it. The greatest challenge simplifying parts for easier manufacturing while maintaining the position of the spigots. This was done by combining two or more parts into one and using datum pins. See Figure 6 on the next page.

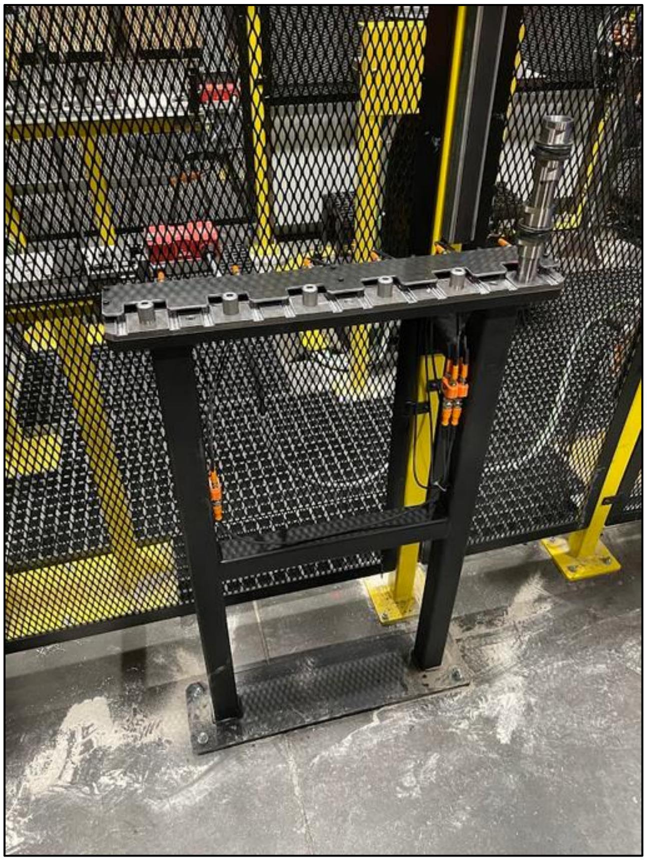

Figure 6: Robot Cell Part Reject Nest

Watonomous Mobile Platform

Summer 2022

Watonomous is a student design team at the University of Waterloo at the forefront in the design, creation, and neural training of autonomous self-driving vehicles.

The guided soft target (GST) mobile platform is a device that allows Watonomous to run high level test scenarios on the autonomous vehicle (AV). There exists GSTs on the market that will serve the same function, however, those GSTs are much too expensive and have functions that are not needed to meet Watonomous' goals for the year. Therefore, Watonomous is looking to build its own GST.

I served as an advisor to the mechanical sub-team that is designing the GST. This included meeting with team members to conduct design reviews and offering advice/answering questions in the team chat.

Autonomous Checkers Robot

November 2019

As part of a first-year engineering design course, myself and 2 classmates were tasked to build a mechatronic system using Tetrix and Lego EV3 Mindstorms.

Our team constructed and programmed a robot to play an entire game of checkers against itself. Built with a 3-axis movement system and gripper built with Tetrix and Lego Mindstorms. The controller was programmed in C with an original checkers algorithm. The project took 1 month to research, design, build, and test the system.

The biggest challenge was for the 3-axis movement system to be precise and repeatable. Using gears and rack and pinion, the movement system was precise enough to move to each spot on the board, pick up a piece and move it to the desired location. As for repeatability, the location of the gripper was stored and updated in the software. The location was updated each time it stopped at a square on the board, due to mechanical imperfections, the location error would build up. To fix this, buttons were placed on the robot that would update the location of the gripper in software to the actual physical location. Each time the robot moved to the zero location in the x or y axis, the button on the robot would be pressed by the frame, updating the location, and eliminating error.

See Figure 7.

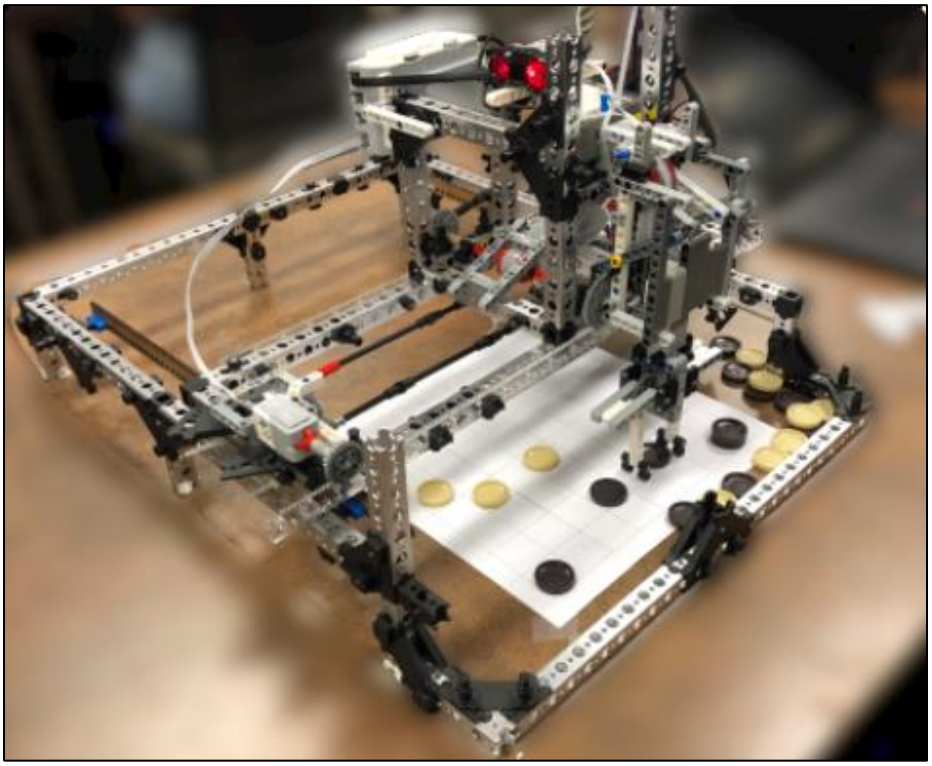

Figure 7: Autonomous Checkers Robot

Zemax DAT formatter

July 2021

The objective was to eliminate the need to manually transcribe large spreadsheets into DAT files for Zemax, which would take multiple hours.

Formats coating transmission data from excel for Zemax DAT file. Uses Python and Python libraries to format transmission data from manufacturers, into a format for use in a Zemax optic studio DAT file.

https://github.com/coopercole/Zemax-DAT-formatter

KPA101-Datalogger

July 2021

The objective was to extract position data from the Thorlabs KPA101 DAQ box and write to a CSV. Third party software must be written since the KPA101 doesn't have first party software to write position data to CSV.

Provided by pythonnet library, using a .NET interface layer to communicate with the KPA101, the python file will extract the signal and PSD location data from the KPA101 and write it out to a csv file. Made for personal use case built off the original code from "ppakotze-sarao" on GitHub

https://github.com/coopercole/KPA101-python-datalogger

Personal Website

July 2021

I wanted to have a personal website because it's cool and it gives me a reason to own the coopercole.ca domain. Built from scratch using HTML and CSS.

https://coopercole.ca/

University Coursework

Studying mechatronics engineering, I get to learn a multidisciplinary blend of topics, from mechanical and electrical design to computer programming and automation technology. Through my courses, I have learned technical skills including C/C++, SolidWorks, 3D printing, GD&T, Soldering, Circuit design.

MTE 140 Algorithms and Data Structures

Structured software design data structures, abstract data types, recursive algorithms, algorithm analysis and design, sorting and searching, hashing, and problem-solving strategies.

MTE 262 Microprocessors and Digital Logic

Number systems, logic gates, Boolean algebra. Karnaugh maps and combinational logic design. Implementation of combinational logic circuits on Field Programmable Gate Arrays (FPGA) boards. Sequential logic and state machines. Programmable Logic Controllers (PLCs) and PLC programming using ladder logic and statement list. Microcomputer structure and operation, I/O, and interfacing and interrupts. VHDL programming. Assembly language programming.

Laboratory work includes microcomputer and PLC programming.

MTE 219 Mechanics of Deformable Solids

Introduction to mechanical response of materials and stress-strain relationships. Behaviour of prismatic members in tension, compression, shear, bending and torsion. Stress and strain transformations.

As part of the course project, built a bridge out of balsa wood that weighed 46.4 g and could hold 14 kg before failure, thus holding 300 times its own weight. See Figure 8

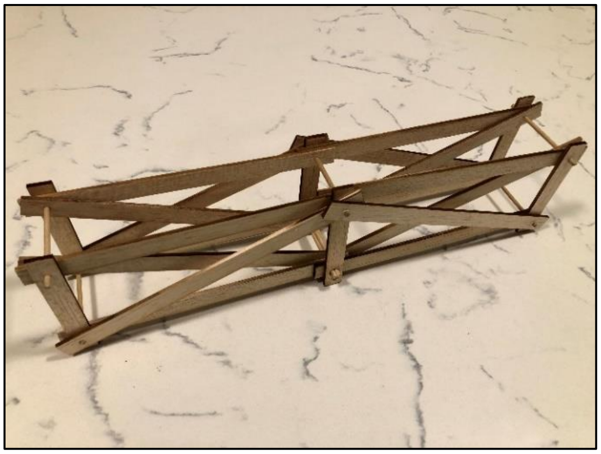

Figure 8: Balsa Wood Bridge

MTE 220 Sensors and Instrumentation

Review of circuit theory; input-output relationships, transfer functions and frequency response of linear systems; operational amplifiers, operational amplifier circuits using negative or positive feedback; diodes, operational amplifier circuits using diodes; analog signal detection, conditioning, and conversion systems; transducers and sensors, difference and instrumentation amplifiers, active filters.

Lab work includes building signal conditioning circuits for robot sensors and actuators. Lab project was to build a line following robot by designing the necessary circuits and soldering components on a PCB. Line following is done by photodiodes and an infrared emitting diode. See Figure 9

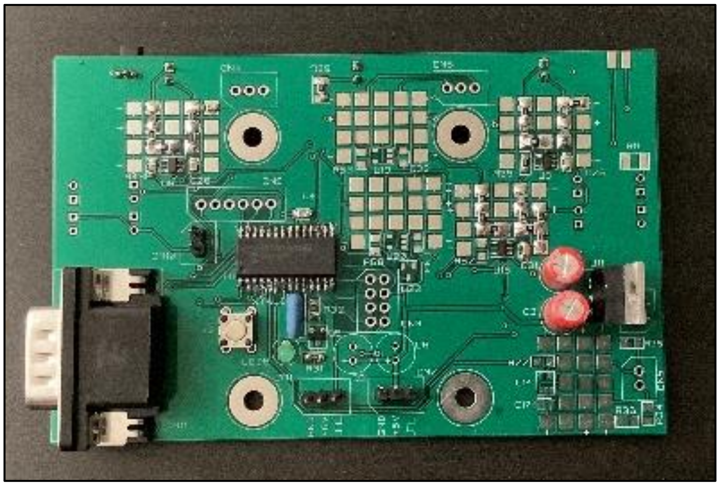

Figure 9: PCB for MTE 220

MTE 241 Introduction to Computer Structures & Real-Time Systems

Introduction to computer organization, basic real-time concepts, process management, interprocess communication and synchronization, memory management, resource management, interrupt handling, concurrent programming, file systems.

Lab work consists of programming in C to implement real time systems on LPC1768 development boards with ARM Cortex-M3 processors. See Figure 10

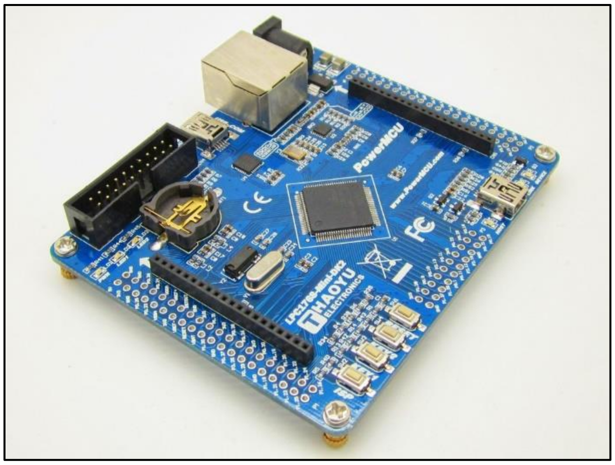

Figure 10: LPC1768 Dev board

MTE 321 Design and Dynamics of Machines

Principles of the geometry and motion in linkages and mechanisms. Computer-aided kinematic and kinetic analysis of mechanisms. Synthesis of mechanisms. Static failure and yield criteria in ductile and brittle materials. Fatigue failure criteria due to fluctuating stresses. Shaft design under static and fluctuating loads. Shaft components, including shoulders, keys, and keyways. Deflections in shafts.

MTE 320 Actuators and Power Electronics

Review of circuit analysis & basic electromagnetic theory. Power electronics: power electronics circuits, H bridges, PWM control, interfacing, power amplifiers. DC servo & stepper motors, AC synchronous & induction motors. Transformers. Introduction to typical speed and torque control techniques of motors.

MTE 325 Microprocessor Systems and Interfacing for Mechatronics Engineering

Synchronization and data flow; interfacing to sensors and actuators; microprocessor system architecture, parallel, serial, and analog interfacing; buses; direct memory access (DMA); interfacing considerations.