ENG20010 Project Report

Mark Saleh, 103994313

Executive Summary

This report details the Engineering Technology Design team project I worked on. Over the course of the unit, we programmed a level crossing system and made a miniature model of it, complete with servomotor-operated boom gates and LED traffic lights.

Table of contents

Introduction

Project topic background

The project prompt concerned a congested level crossing for which the Transport and Traffic bureau had requested a redesign. The level crossing was just before a station serving much of the locals in their commute to and from the city, while the road connected to a busy shopping district, schools and medical services. Furthermore, it was near a freeway on which traffic often built up. Due to the presence of nearby heritage buildings, removing the level crossing was not an option. Our task was to propose an "efficient and sustainable"[1] system for the management of this level crossing, which is based on the traffic flow of the local road and rail networks.

Project description

Our project sought to implement a modernised, safe, efficient, and sustainable sensor-triggered level crossing system with boom gates and light-and-sound warning systems. This included two IR sensors to detect oncoming trains and trigger the loop, which can also be triggered manually by the train's conductor. This loop first triggers traffic lights on either side of the road, making them yellow for a few seconds then red. (The number of seconds is easily adjustable). After several more seconds, the boom gates close until the train is past, then they reopen, and the red lights simultaneously turn off. Below is a more in-depth explanation of the program and mechanism:

Figure 1: The model level crossing

The project was programmed using LabView with an NI-DAQ. Two IR sensors, to detect oncoming trains, were connected to the same pin on the DAQ, and another IR sensor was connected to a separate pin attached to the road to measure traffic levels. Two servo motors were connected to the same pin, in order to control the boom gates on either side of the track. Finally, two yellow LEDs were connected to a pin and two red LEDs to another pin, so that each traffic light could have a red LED and a yellow LED.

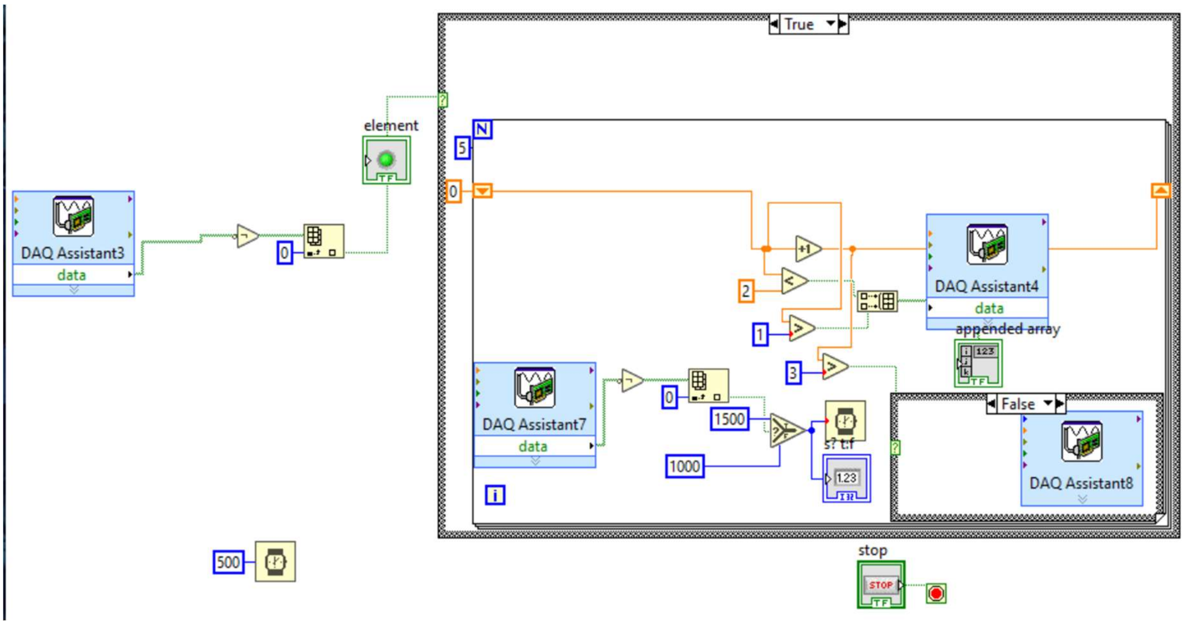

Figure 2: The VI for the project

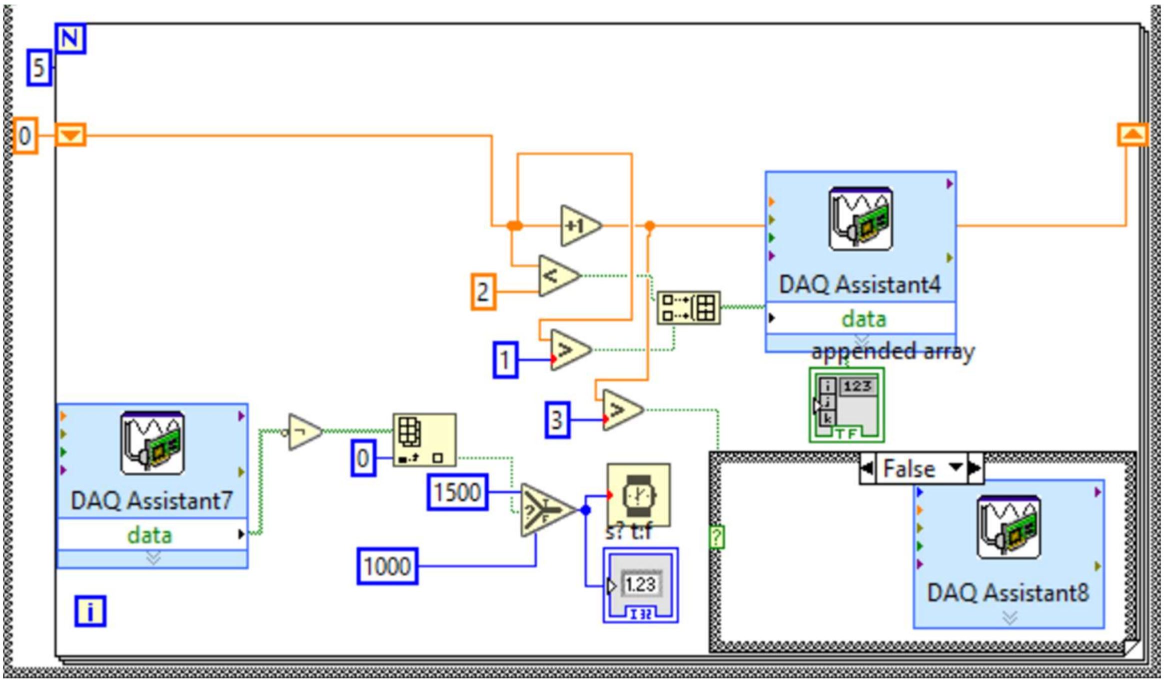

Figure 3: The while loop within the case switch

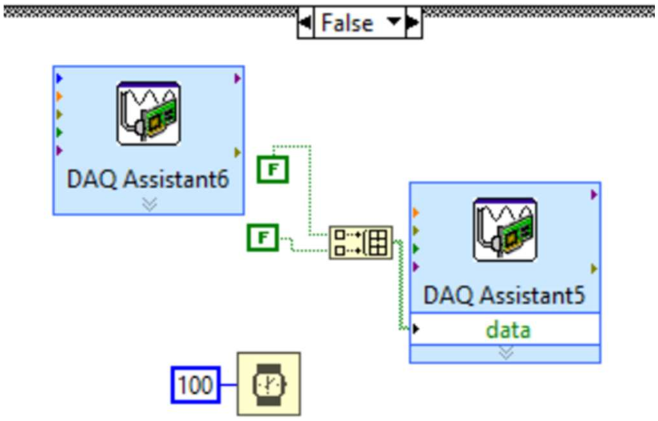

Figure 4: The false case of the case switch

The leftmost DAQ assistant in the VI (Figure 2) is the two railroad IR sensors. By default, they generate a true signal, but if either IR sensor detect infrared rays, the DAQ Assistant would generate a false signal instead. A NOT operator is used to flip true and false, since it is more comfortable to work have "true" mean "A train is detected" and "false" mean "No train is detected". When a train is detected, it triggers a case switch in which there is a while loop (Figure 3). This for loop repeats five times, each time incrementing a counter number. (It was originally made as a while loop, which is why the loop number is not simply taken from the top left). It contains another DAQ assistant measuring traffic conditions: when there is no traffic, the loop repeats every second, but when there is traffic it repeats every 1.5 seconds, thus making the cycle 50% slower and giving the cars more time to stop.

The counter number controls the traffic lights and boom gates. For two seconds, the yellow lights turn on, then the red lights remain on. The status of the yellow and red lights is made into a 2x1 array and fed to a DAQ assistant. 4 seconds after the loop starts, the boom gates close. This is accomplished by another case switch, one of which opens the boom gates and the other closes it. These durations are unrealistic but were selected for demonstration purposes and can easily be adjusted by changing the constants in the VI. Once the railway IR sensors no longer detect a train (or if the 5 loops are over), the outermost case switch switches to false. The false case (Figure 4) simply reopens the boom gates and turns off the red and yellow lights.

Project scope/objectives

The scope of our project was to design an efficient and safe level crossing to relieve congestion. Our design was efficient, as it does not require much energy (the model worked using just the 5V pin on the DAQ), and therefore could be powered with solar panels. The boom gates and traffic lights can also be manufactured from recycled, environmentally friendly materials such as aluminium, stainless steel or even scrap metal. Our original design contained many safety-enhancing features such as warning systems using light and sound, and gates that close on the footpaths on either side of the road, and manipulation of the speed limit on the freeway during peak hours to slow down the pileup of traffic, and many road signs to inform non-local drivers. Due to hardware limitations (such as lacking a bell and a speed limit display), not all of these measures could be implemented, but the majority were.

We had to make several assumptions about our scope. For example, we assumed that the train cannot be stopped, and that the existing path of the road or rail cannot be modified. We assumed that what we can control is the traffic flow, as well as the construction of boom gates, traffic lights, signs, and other components of a level crossing.

Individual contribution

My contributions to the team effort were largely the LabView coding and the wiring of the DAQ. My laptop was the only one on the team on which LabView worked with the DAQ, so due to circumstances outside of my team's control, they could contribute little to the VI (although Fathima, Haritha and Chrishelle all helped me with it). The DAQ was usually kept at my house, so I largely worked alone on the wiring as well.

I made minor contributions to the model level crossing. For example, I threaded the wires through the Chatime straws for the traffic lights, and connected the wires inside the traffic lights and inside the box. I also made rudimentary road signs, but these were replaced with better, printed road signs by Chrishelle.

Learning outcomes

Below are all of the learning outcomes of this unit, and how I believe I have accomplished them.

Apply a systematic approach to engineering technology design

Our team's approach to the project was certainly systematic. We met on Mondays to work on it, having our meeting with Kafeel at exactly 4 every Monday. On Tuesdays we would meet again in class and work more on it. The distribution of the workload across the various team members and weeks was also fairly systematic; for example, the final model was left until the last two weeks, after the VI no longer needed modification.

Apply knowledge of design fundamentals to engineering technology challenges

We had to apply knowledge of design fundamentals to the unique challenges presented by this project. The miniature model required a deep understanding of level crossing design, which was aided by my familiarity with a level crossing in my local region (at Kensington Station) just like the one described in the project prompt. This level crossing was used as the basis for our team's design. Furthermore, the model also required some knowledge of arts and crafts; it was made largely of popsicle sticks, tape, straws and a cardboard box.

Find, organise, and make decisions on a range of topics related to engineering technology design

Every aspect of this project required many decisions in order to come to fruition, and with 5 team members there were sometimes disagreements. The decisions ranged from what materials to use for the model, to how many seconds long each delay should be, to the dates of our meetings. However, this issue was significantly mitigated by the Discord server Fathima created for our team, as it made it possible for the entire team to remotely discuss such issues at any time, and created an archive of past decisions. Decision-making was also greatly facilitated by the weekly meetings every Monday.

Use engineering technology to develop and present design solutions

LabView, DAQ, servomotors, LEDs, and IR sensors are all engineering technologies, and our team combined them to develop and present a design solution. LabView in particular was useful as it was the interface through which the program was written, and the DAQ served to translate the computer program into the real world.

Communicate within teams and stakeholders using appropriate verbal, written and technological approaches

One crucial aspect of our project was the PowerPoint presentation that accompanied it. It utilised appropriate verbal and written approaches to market our proposal for a level crossing design. My contributions to it were the slides regarding the VI.

The project brief also contained language designed to emulate the style directed at stakeholders. My contribution to that was the Design Concept section.

Reflection

Methods

Our choice of logic was based on the weekly assignments given to us in the first half of the semester. These assignments began from the complete basics (which was appreciated, as we did not have any prior experience with DAQs or with LabView), and went LabView logic and how to use a DAQ with LEDs, IR sensors and servomotors. The logic we used in LabView was simply based on derivations and combinations of these assignments.

As for the model, it was made using available materials. The main frame of it was a PS5 box. The rails were two lines of tape, with popsicle sticks chopped in half hot-glued across its length. The traffic lights were also made of cardboard, with thick straws (intended for bubble tea) used as the stem to allow wires to pass through. The boom gates were made of thinner straws from Hungry Jack's, selected due to their red and white striped design which resembles real boom gates. Finally, the road signs were printed on paper and stuck to popsicle sticks, which were fixed into the box by using the screwdriver to poke holes inside it.

Technical learning

Throughout the course of this project, I learned many new skills relating to engineering and technological design. These include the use of a visual programming language, which I had never done before, the wiring of servomotors and IR sensors (which I had also done before) and the usage of a DAQ (which was also my first time). I also deepened my experience with breadboards, LEDs, and other components of such systems, which I had gained through a previous unit using Arduino.

Project Outcomes

This project had several notable outcomes. Our team accomplished the design and construction of a miniature level crossing system that was efficient, safe, and sustainable. We used technologies and methods that were new to us and managed to communicate our proposal to (fictional) stakeholders using appropriate written and verbal approaches. Overall, it seems to have been a success.

Conclusion

In conclusion, this level crossing project provided my team and I the chance to learn more about engineering and technology design through LabView and NI-DAQ. We managed to program a level crossing and then construct a model of it. We also proposed our design to fictional stakeholders. In the future, I will likely remember the lessons learned from this unit on teamwork, design, and engineering technology.

References

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