Integrated Design Project Final Report yhw25

System developed and strategy

In the Integrated Design Project, we designed an Autonomous Ground Vehicle (AGV) which could follow a line, navigate to, and grab/ release targets. Using computer vision, my laptop takes the camera feed and identifies location of the target and the AGV. With this information, it then decides on the action needed to be taken and communicates to the Arduino via a mobile hotspot.

Decisions were made with one main strategy in mind - we preferred to introduce simpler solutions. This is because a simple solution would result in less components and moving parts – reducing the chance of a failure. Alongside the simple approach, efforts were taken to lessen integration required between different modules. For example, by using computer vision, it meant that we would less sensors are required (we didn't need the ultrasonic sensor), which lowered the workload on the electrical team.

My contributions to the project

I made countless contributions to the project, some small, some large. The most significant of which is the project management, computer vision and navigation.

As the Project manager, I had to make key decisions regarding the project, with the most significant ones detailed in the next section. Alongside that, I had to work on the bureaucratic side of the project. I directed the structure of the presentations and contributed heavily towards the content. I also produced a spreadsheet which could automatically generate Gantt Charts – this meant that other team members could update the Gantt Chart at will (and produce a chart of reasonable quality without expending too much effort).

I also exclusively worked on the computer vision and the navigation for the AGV. As I have experience in coding in python, learning how to work with OpenCV was easier than expected. I experimented with different designs for the trackers, firstly by using two circles, and then finally deciding on two rectangles in a T shape. The computer vision was able to identify targets within the first week and track the AGV within the second week.

I worked on the navigation algorithm, however this proved slightly more challenging as the motor cannot execute instructions perfectly due to mechanical limitations. Therefore, instead of sophisticated pathfinding algorithms, I opted for a simple "rotate and go" implementations, where the movements could be adjusted using feedback algorithms. The most difficult part was getting the AGV to recognise the T junction and transition to line following reliably, many ad-hoc solutions which were thought up on the spot was implemented here. In the end, apart from some edge cases (which fortunately didn't happen in the final competition), the navigation performed really well.

Major decisions made

I made a lot of decisions during the course of the project, but the most significant was committing to computer vision and giving up the pulse counter.

In the introductory software talk, computer vision was introduced as a high-risk strategy, it was said that teams that used computer vision had generally lower scores. However, upon initial investigation it was concluded that computer vision was significantly more reliable than the ultrasonic sensor. Furthermore, we were able to get a test demo working in the first week. Upon these successes, we decided to fully commit to computer vision, minimising the number of sensors and electronics needed.

This was seen as a bold strategy at the time, however it is evident that it turned out to be the right decision. Using computer vision, we were able to achieve a score of 100 in the final competition and finish in a respectable 2nd

place. The scores gained by other teams indicated a clear favour to computer vision as well, the 3 teams with highest scores used computer vision and the maximum score for teams without computer vision was just 20.

Upon the failure in the preliminary competition, and multiple setbacks on the project as a whole, I realised that I needed to sacrifice some features in order to have enough time to properly test the AGV. The one that made way was the pulse counter – reviewing the scoring system led me to the conclusion that optimising the grabber and navigation is far more important. I also realised that attempts to integrate the decision making for pulse counter into the navigation would bloat the complexity of the navigation algorithm significantly.

This was an emotionally difficult decision to make, as the electrical team have already spent so much time and effort trying to get the pulse counter to work and are very close to a breakthrough. It is a shame to see their efforts nearly go to waste. Despite this feature being moved to low priority, the electrical team managed to get a functioning pulse counter working in the end, albeit not very reliably. In the final competition, it is working independently and has no influence on the navigation.

It is hard to say, but I believe I made the correct decision. Even if the pulse counter was working perfectly, the marks gained by moving, identifying and grabbing the correct target might not even worth the time which could be used to collect other targets.

Team management

The management structure of the project is simple- the project is split into 3 sub-teams - Mechanical, Electrical, Software. Since those are wildly different disciplines, each sub-team would have a different approach to solve the problem. As a result, each sub-team had significant autonomy regarding internal decision making, however the over direction and key decisions are made by the project manager.

This worked alright, but not fantastically. The main drawback was that it was difficult to find the time to do integrated tests, especially for mechanical and software, because the mechanical team constantly took apart and rebuilt their grabbing mechanism. The first integrated test for the gripper was on the 4th week, which was far too late for my liking.

Performance in competition

In the competition, most things went according to plan. We were able to traverse the tunnel using line following, and by using computer vision we were able to navigate to the target and grab it without dragging. As a result, we were able to successfully recover 3 targets within the given time frame. However, we were unable to recover the 4th target (due to time limit), and the navigation system did not take any inputs from the pulse counter (so AGV would collect robot requiring charging before those requiring service). Those failures of meeting the task specification were intentional – quality was sacrificed in order to complete the task in the given timeframe of 4 weeks. However, there was unexpected hiccup at the end - the AGV thought it was a good idea to bring one of the targets as a souvenir when it returned to its starting area. This was unexpected behaviour and hasn't happened before during our testing.

If there is "next time", the one thing I would do differently is to focus on designing a more reliable grabber mechanism. This would mean constant iteration, and attention put on the integration between software and mechanical. I would make sure the mechanical team know how to test the grabber using the software as soon as possible, which would give them enough time to iterate and improve upon it.

Mass production?

The major change that would need to be introduced in order to enable usage of multiple robots is to overhaul the computer vision detection. Currently, the computer vision is designed to detect one robot only, however if many robots are present the algorithm would not work.