

Garmisch Wong

Π Mechanics

Γ Design

Ω Electronics

Λ Software

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Foreword



The following are the design and engineering projects that I have accomplished and experienced, and I would like to share them with you. They are listed in chronological order to show my persistent passions and long-lasting interest, and the journey of learning and exploring in the realm, illustrating the process of problem identification, conceptualization, formulation of alternatives, problem-solving and users' experience.

The Turret



Date: Summer 2015

This is an auto-aiming turret which I have built at the age of 11 for the purpose of fun and practicing mechanics and software manipulation. It uses a Lego NXT ultrasonic sensor to detect the target and calculate the trajectory accordingly. I have also uploaded some videos of it onto Youtube to share my design.

This project is significant because it is one of my first projects and it marks the beginning of my journey in design and robotics.



[Click to watch the video](#)

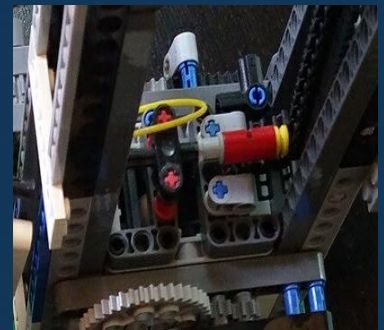
Safe Lift



Date: April 2017

This safe elevator project is a self driven learning one where I investigated and learnt mechanical safety features of elevators. This project was inspired by the unfortunate escalator accident that happened on March 25th 2017 (朗豪坊電梯溜後意外). At that time, I considered myself an inventor, and I questioned, "How could this have happened? Why didn't the safety systems prevent this accident?".

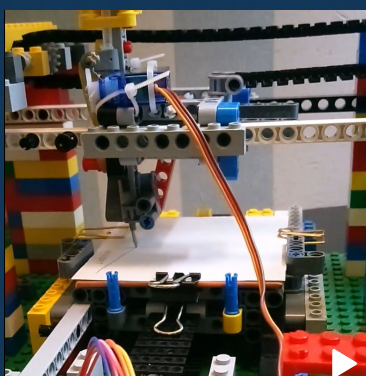
As I researched on the topic, I became interested in safety systems. I had an idea, which I wanted to test, therefore, I built a prototype elevator to test my design. It was a spring loaded mechanism which detects when the cable sags, thus deducing that the cable has snapped, and the brakes will be engaged. The brakes then clamp onto the wall of the lift shaft, and use friction to slow down and stop the elevator. This design does not use electricity, making sure that the safety system works at all times.



At last, I shared this prototyping experience with my friends to let them know more about safety mechanisms. I learnt a lot about redundancy, single point failures, reliability, independence of backup systems. These concepts greatly influenced my future projects.

The close up of the braking system. The red part is the brake.

2D printer



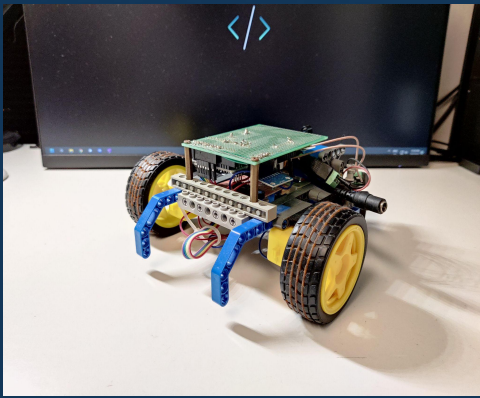
Date: Summer 2018

This is my first attempt to design a useful machine. At that time, consumer-grade 3D printers were relatively new and expensive, therefore, I decided to make one myself. I have learnt about different types of motors and how STL files are related to Gcode and how to translate Gcode into motor movements. [Here](#) is a demonstration of the machine.

This project raised my awareness on "real world factors/imperfections". During the design phase, I did not account for the flexibility/elasticity/elongation of the plastic that I used to build the machine. These factors added up and caused mechanical backlashes and the movement of the print head become inaccurate.

This experience is a reminder for me to consider real world factors and limitations/constraints, and the importance of design tolerance.

Vacuum robot



Summer 2019

Seeing that my mum needs to do housework like vacuuming the floor, I would like to help her by designing and building an automatic vacuum robot.

As my budget was limited, so I went with some very cheap motors and wheels. This caused problems, and the car was unable to drive straight.

I first suspected that it's a wiring problem (perhaps inverted polarity of motors), then software (incorrect pin assignment). At last, by using the slow motion camera on my phone, I discovered that the right side motor is spinning much faster than the left one. To solve this, I used a gyroscope and a very basic PID system to actively correct the error. I also upgraded the chassis to mount the motors securely. The video on the right shows the before and after comparison.

As I wanted to include a larger vacuum motor, I modified the design to make the car more compact. To eliminate loosen wires, which sometimes happen due to vibrations, I learnt to do soldering to firmly secure the wires.



As shown in the above video, the robot is driving much more straight right now.

Communication device

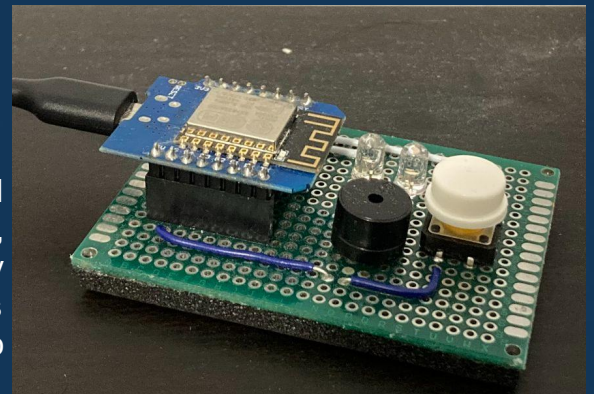
August 10th to 13rd 2021

It is a network connected communication device that I designed for my friend. His requirement was simple, making a device that could be triggered to ring by someone remotely. He needs this because his phone is very unreliable, and he wants someone to be able to remotely wake him up in case his phone malfunctions.

I was tasked to design and make such a device in 3 days. This device is considered as a consumer product, which has to be easy to use and configurable. Also, there is no way to repair it once it belongs to my friend (He is going to study overseas).

This is the device, 1 buzzer, 1 button, 2 LEDs and a microcontroller, soldered together to ensure reliable connections. The reason for the 1 button design is to make it simple to use. To me, this rapid prototyping project is one of its kind, because I have never designed anything that cannot fail, needless to say in such a tight timeline. It felt like making a satellite to me, once launched, there is no way to do anymore repairs on the device.

Since he is moving to another country, I could not hardcode the wifi password. That means the device must be configurable without wifi. I solved this by allowing the device to turn into an access point, to which my friend's phone can connect and configure the device using a browser.



Smart home alarm clock system

Since 2021 summer

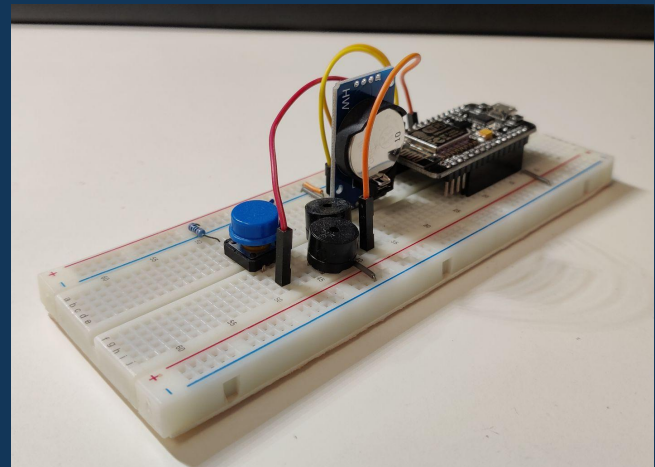
I have 2 problems with ordinary alarm clocks. First, the cancel alarm button is easily mistaken for a snooze button. Secondly, they are too abrupt and sudden, and the alarm sound scares me every morning. Everytime I woke up, I can feel that my heart is beating very quickly. People say that it is normal, and this is how alarm clocks are supposed to work, I disagree. Therefore, I started this project and built my own alarm clock system.

My new alarm clock system uses light to gently wake me up, and also uses sensors to detect my presence on the bed. The system is controlled through an app, where I can set the alarm time, allowing ease of access. This is so much better than ordinary alarm clocks. First,

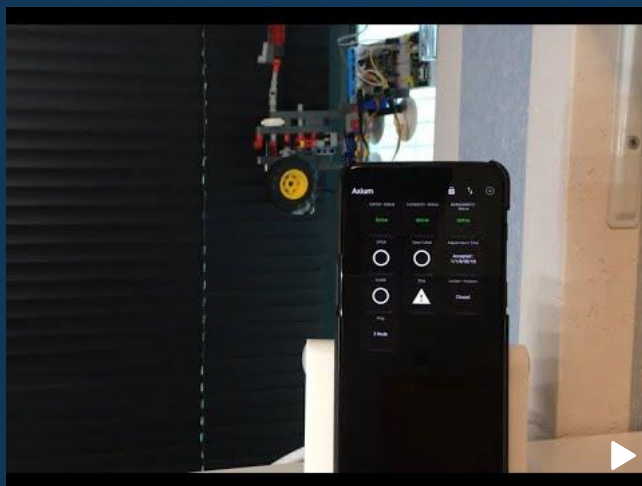
I don't get scared. Secondly, not only can I wake up gently, my internal clock takes the light cue and wakes up my organs and brain before I become conscious, and I can have a much more refreshing start of the day. Most of the time, I will be woken by the light, but in case I don't, the sensors will detect the weight exerted on the mattress, and sound an alarm upon the set alarm time.

Since the consequence of the failure of this system is very significant, I incorporated lots of fail-saves to ensure its reliability. Like having backup methods to keep track of the time (Real-time clock module, and network time protocol), and having physically separated modules carrying out the same tasks. This will ensure that I will wake up at the right time.

One of the modules can open blinds in my room. I designed a gearbox that allows manual and automatic control of the blinds, and have designed several preventative protection designs to protect the motors from over spinning, thus preventing damage to the blinds.



One of the 4 modules of the system



The video on the left demonstrates the motorized control of the blinds control through the app.

I have applied lots of my previous knowledge and experience when designing this system, while gaining new ones. I am using this system daily and this is an ongoing long project. I have applied for the HKEI Competition using this project, and have created [this document](#) detailing the fail save systems, scientific backing, design process, user experience and more. The document is stored on myself hosted Nextcloud server (Please allow up to 15 seconds for it to load). [Here](#) is a backup link for the same document.

Media Production Team

The Media Production Team is a team which I am glad that I joined during secondary school. Other than teaching me photography, filmmaking and video editing, I think the most important thing the team and the teacher, Mr. Au, gave me are management skills, leadership skills and a much deeper understanding of teamwork and mentorship. These experiences and soft skills greatly helped me during later events, like the HKUST Robotics Design Contest. The following are photos I would like to share. [Click here](#) for more pictures on my next cloud server.



A picture of me taking picture



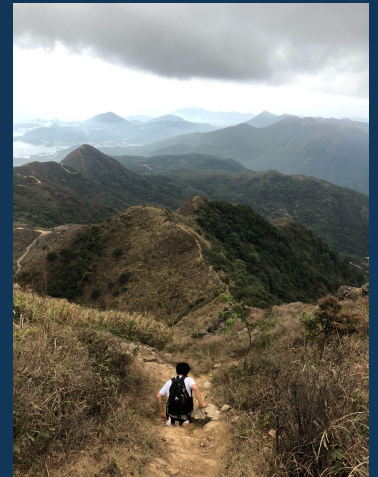
17 Dec 2019

Taken in the school sports day, showing an athlete crossing the finishing line.



21 June 2021

Setting up camera to capture the solar eclipse



26 Feb 2021

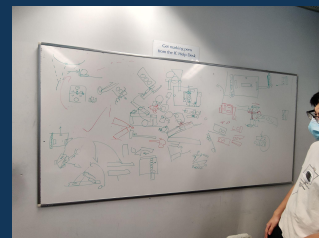
Picture taken during a hike, to show the vastness of mountain

The HKUST Robot Design Contest

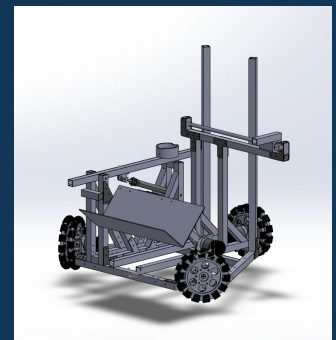
Nov-Dec 2021

The robotics design contest was held by the HKUST robotics team. At which, I was the team leader of Team Fire (Team Five) and the leader of the mechanics team in Team Fire. It is an experience where I learnt complicated CAD and got to design a robot from the ground up.

Apart from technical enrichments, this event is a precious chance for me to practice my leadership skills. I was given about a month of time to bring a group of nearly complete strangers together, achieving the goal of completing a robot for the competition. It was not easy to get the balance of time, workload, communication and feelings of teammates. Dictatorship might be an appealing choice for some, but I chose leadership, to inspire, to encourage, to build a sense of belonging, with a welcoming communication atmosphere, with passion and empathy. We did it; we successfully built a robot; we got the best mechanics design award; we got much more than just teammates; we got new friends and bondings.



Research and planning



Design & visualization



Building



Debugging



Competition

Flappy Bird AI

This is my most recent software only project, where I learnt about machine learning (ML). I first researched the technical aspect of machine learning through YouTubers, like 3blue1brown, to learn about how it works in theory, which also increased my understanding of its capabilities.

I then choose flappy bird as the game (problem to solve). I then choose the "Neuroevolution of augmenting topologies" genetic algorithm. It simulates natural selection. It is not the most efficient algorithm, but it is easy to understand and is more than capable of handling such game.

At first, the results were mixed, sometimes it can generate birds that can fly for a long time without losing, but sometimes it would eliminate birds that performed optimally. It turns out that there is a bug in the fitness score calculating algorithm causing all this. After fixing the bug, it is able to generate a reliable bird within 10 generations. Click [here](#) or the above image to watch a demo.

I am glad that I did research beforehand, understanding the mechanics behind the "blackbox". This allows me to pinpoint the problem very quickly.

HKUST Robotics Team



After passing the robotics design contest, I was invited to join the mechanics team of the HKUST Robotics Team. It is truly my honor to be able to join this team as I am getting a lot of hands-on experience, like cutting aluminum and carbon fiber tubes, 3D printing, laser cutting, milling, handling large machines, identifying and handling materials and more. This team granted me not only access to many machines that I couldn't possibly have in my home but also years of experience in the robotics team. The Robotics Team was founded in 2004, and it has 18 years of experience of building robots. Their methods of standardization, such as naming scheme and division of labor will help me work on future projects more efficiently.

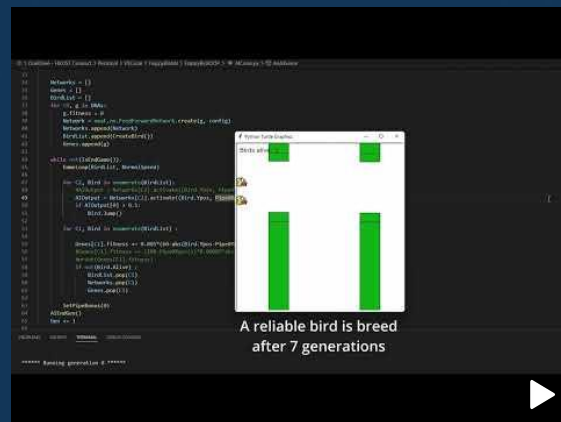
It's a pleasure to work in the Robotics Team as there are many competent mentors guiding you when they give you tasks, and each mentor has their unique strengths. They don't mind answering my questions, and are very willing to use graphs, drawings and past examples to explain and solve my questions. When I ask some questions deeply into a certain domain, such as tenon, 3D printing, logistics, etc, they are not hesitant to find me an expert mentor in that domain to answer my questions. The Robotics Team is really a knowledge and experience bank that I am glad to be a part of.



Some of my designs, from left to right:

- 1) A football elevator + a primitive ball turret at the top
- 2) A football loading system
- 3) A football turret, Gen1
- 4) A football turret, Gen2, reduced weight & size

[Here](#) are 2 short videos showing the testing of the first two mechanism. The last 2 mechanisms haven't been built due to closure of the labs.



Video demo

Computer Stand Project



Date: Since December 2021

My laptop has a problem as the screen wobbles whenever I use the touch screen. I use my laptop and stylus to jot notes during lessons, however, I could not rest my hand onto the screen, because the screen will wobble and the laptop will flip over. I looked for a solution on market, however, they all use either glue or only have fixed angles. To solve this problem, I have to design a stand, and I have a few requirements for the design.

Requirements:

- 1) The design should allow any inclined angle of the screen
- 2) The design cannot use glue or tape, since they will leave a stain upon removal
- 3) The mechanism should be easily removed and reinstalled
- 4) The mechanism has to be collapsible when unused
- 5) The mechanism has to stay attached when the screen of the laptop closes

Future development

- 1) Add a component for attaching the stylus

Click the picture above or [here](#) to watch the concept video.



Prototype 1 test video, click to watch. In the test, I discovered that the teeth of the gears are too small which causes slippage.

Other Interesting Projects

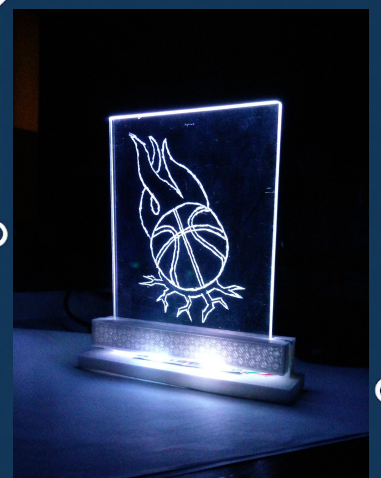


I use this nextcloud server to learn Linux, and use it as my NAS. There are plans to upgrade the hardware to make it more reliable.



This is a snapshot of a Blender animation I am currently working on. It tells a story of a determined athlete preparing for competition during the pandemic.

The picture above shows part of the 3D stadium that will be used in the animation.



This is a decorative item that uses acrylic and LED, which I learnt woodwork and 3D printing during the production.

Epilogue

The aforementioned are projects which I have done throughout the years or still being worked on. They are the proof that I am a continuously self-driven and explorative learner, who loves learning through projects and strives to equip myself with knowledge and skills from different domains, such as problem solving, design thinking, testing, prototyping, teamwork, and more. I would like to be a well rounded innovator, who can solve problems or improve quality of life by designing adequate systems and products that are practical, convenient, user-friendly, ergonomic, featureful and eye-pleasing because a product that only solves a problem no longer meet modern standards and clients' general expectations and aspirations.

I believe that the Integrated System and Design (ISD) program is a great combination of engineering and design. I would really want to join this program to enrich myself and gain more design experience, such that I can become a proactive and successful innovator who contributes to improving the world.