ON-CAMPUS DELIVERY ROBOT

by

MUHANNAD SAEED ALGHAMDI 1846525

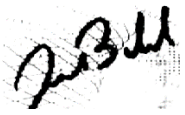
SULAIMAN ABDULLAH ABBAS 1845862

WAEL RABAH ALDHAHERI 1846987

TEAM NO.: 03 FALL-2021 INTAKE

Project Advisor

DR.MOHAMMED BILAL

CHECKED AND APPROVED (ADVISOR): 

Project Co-advisor: **N/A**

Project Customer: **DR.MOHAMMED BILAL**

SDP Evaluator: _____

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
FACULTY OF ENGINEERING
KING ABDULAZIZ UNIVERSITY
JEDDAH – SAUDI ARABIA

NOV. 2021 G – RABI' II 1443 H

ABSTRACT

ON-CAMPUS DELIVERY ROBOT

According to our information gathering, it is apparent that there is a need for an on-campus delivery solution. Which would benefit the administrators in efficiently completing their work and students by reducing time wasted going back and forth between buildings.

The university campus consists of different terrains which might make traversal more challenging for a ground robot. In addition to that, there are moving objects (people, cars) which might necessitate obstacle avoidance.

We want to create a unified and comprehensive delivery network across the KAU campus without human involvement.

Our lower-level objectives are connecting the whole university buildings into a single automated delivery network, improving productivity of employees/students by saving their time, reducing the use of fuel and manpower in the delivery process.

Our higher-level objectives are Pushing to increase development in the tech field industry in Saudi Arabia, raising awareness to decrease the carbon emission, by providing electrical alternatives., encouraging upcoming generations to R&D autonomous solutions.

For the alternative solutions, we started by brainstorming some ideas for possible solutions. We then generated some new alternatives using a morphological chart. We then ruled out some of the alternatives using a KTDA table. After the analysis, the alternatives that passed are the RoboDog, Robot Train and the Ground Robot.

We then compared the pros and cons of each alternative. The chosen solution was the Ground Robot. We picked the ground robot because it had the lowest cost, it is moderately complex, and the parts needed are easily obtained.

We then tried to further improve our baseline design. We made some adjustments, the most substantial one was replacing some of the parts (wheels, motors) with a hoverboard. In addition to that, we added ventilation holes and a hole for cable management.

Index Terms — Navigation, Obstacle avoidance, delivery robots

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CHAPTER – 1 INTRODUCTION

1.1 ABOUT THE PROJECT

The project is an ambitious attempt at creating a delivery network robot. Furthermore, this robot is capable of delivering different types of shipments. An important feature is the autonomy of the robot, needing just the destination and package to be given in order to deliver.

The main issues this project is trying to reduce or solve are plenty. To name a few, saving time for the workers since they have to leave their office and deliver papers themselves, aiming to reduce the usage of fuel and manpower and encourage automation in KSA.

1.2 BACKGROUND

There are a few markets that might benefit from delivery services within the campus, in this section we explore and gather more information about some of our target users and we have also surveyed the campus to study the infrastructure.

Potential Customers

First, to find out if there is a problem with document delivery on campus, we consulted with some of the administrators in the faculty and we learned that most of their administrative work is done online. Although, some documents that need to be filled/signed are delivered physically.

Another potential customer are students who sometimes need to send/receive items such as books, lab equipment, snacks even. Especially since for example, engineering students have classes in different buildings that aren't very close to each other.
After surveying the campus, we noticed the following things:

1. There are different terrains in the campus: streets, tiles, mud, grass, etc.
2. Often, there are students in the halls between buildings.
3. Rarely are the streets empty during classes times.
4. The are some ramps for wheelchair users. *[i]*

[i] Might be relevant in case of ground robots.

Campus Map

As shown in the figure, the distance between the faculty and the deanship of administration is approximately 240 meters. And the distance between the faculty of engineering and the faculty of science is 400 meters.[1]

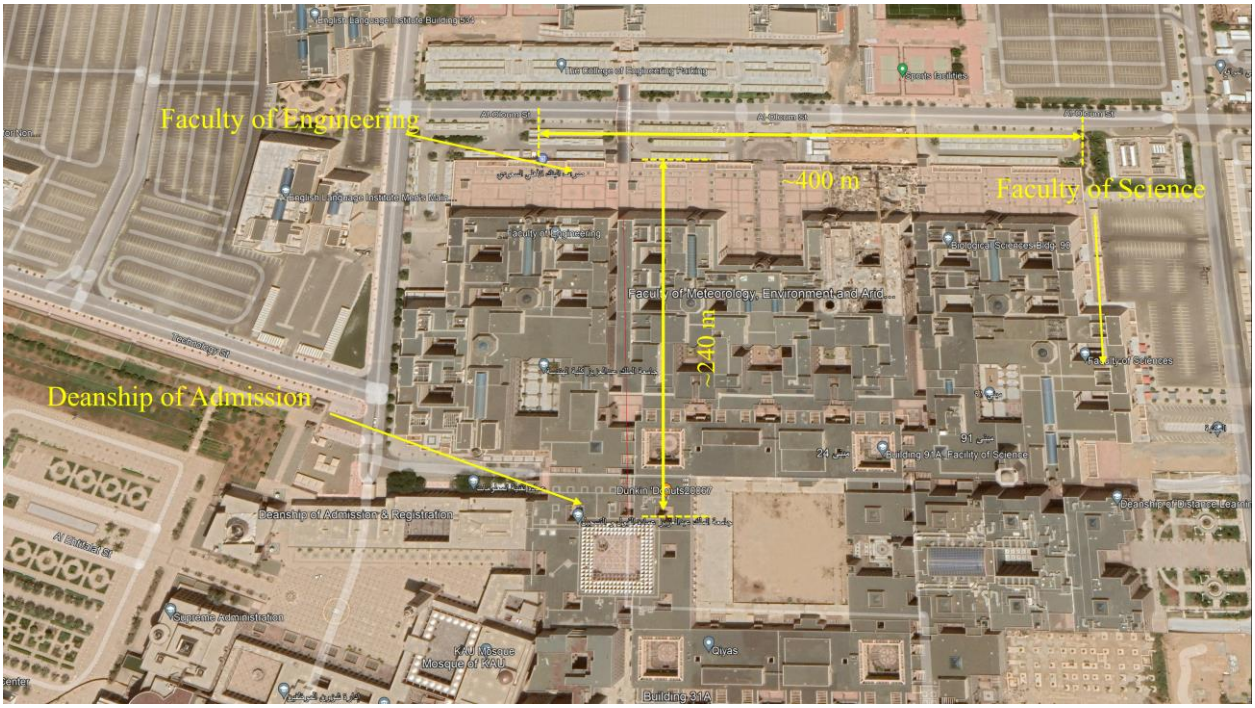

Figure 1 Campus map[1]

CHAPTER – 2 CONCEPTUAL DESIGN

2.1 SITUATION DESCRIPTION

The university campus consists of different terrains: roads, tiles, grass which might be challenging to traverse for a ground robot. In addition to that, there are moving objects (people, cars) which might necessitate obstacle avoidance.

2.2 DEFINING THE PROBLEM

Create a unified and comprehensive delivery network across the KAU campus without human involvement.

2.3 PROJECT OBJECTIVES

Lower Level:

1- Connect the whole university buildings into a single automated delivery network.
2- Improve productivity of employees/students by saving their time.
3- Reduce the use of fuel and manpower in the delivery process.

Higher Level:

1- Push to increase development in the tech field industry in Saudi Arabia.
2- Raise awareness to decrease the carbon emission, by providing an electrical alternative to gasoline-based vehicles.
3- Encourage upcoming generations to research & develop autonomous solutions.

2.4 APPLICABLE ENGINEERING STANDARDS

We might need to follow some standard that would become more apparent once we know all the components that we need but for now we are sure we would use batteries. The battery we use should follow the **ISO 9001** standard. Which is a quality management standard. Another option is to use batteries that are certified by a safety certification company. If for example, we buy a battery that is **UL** certified that means it has been tested and certified for multiple standards including: **UL 1642** lithium cell**, IEC 61960** for the

Performance of Rechargeable Lithium **IEC 60086-4** for Non-rechargeable Lithium depending on the battery. etc.) in defining all the constraints in the Product Design Specifications, especially the musts.[2]

2.5 REALISTIC CONSTRAINTS

- The cost of the project must not exceed 5000 SAR.
- Project must be completed before the end of Term-2.
- Causes no harm to the surroundings.
- Battery life lasts for at least one complete trip (2 km).
- Guarantees the privacy of the packages.
- The artifact should withstand normal heat (36° C) for the duration of the trip (2 km)

2.6 PRODUCT DESIGN SPECIFICATIONS (PDS)

Functions	• Traversal of the campus • Carrying the package • Navigation • Maintain the safety of the package
Specifications	• Carry packages up to 80 Kg • The Battery life lasts for a complete trip • Operate within 2 Km range • Operate within 5 km/h.
Constraints	• The cost of the project must not exceed 5000 SAR. • Project must be completed before the end of Term-2. • Causes no harm to the surroundings. • Battery life lasts for at least one complete trip (2 km). • Guarantees the privacy of the packages. • The artifact should withstand normal heat (36° C) for the duration of the trip (2 km)
Musts	• The ability to move within 2 km range of the Engineering building autonomously on paved roads. • Ensures the safety of the packages. • Includes a storage unit for the shipments. • Tamper proof electronic components. • Made from durable material. • Operate within 5 km/h. • Can carry weight within (80kg).
Wants	• The ability to move around the whole campus autonomously on paved roads. • Neat design. • Can carry weight within (120kg). • Can charge using charging stations.

	• Costs less than 2500 SAR.
Assumptions	• The university network covers the whole campus or at least a 4G connection is available. • No lock-down or any action that can limit our visits to the targeted campus. • No temporary or constructional change on the campus map. • It is allowed to operate prototypes within the campus roads & facilities.
Scope	For this project, the following must be clear for all parties: • The design is targeted to be specific for the KAU Campus. • The information gathering will be done with the guidance of the advisor and includes all the team members. • Team members will provide all the required resources needed to implement the solution. • Team members are responsible of any financial obligations that could be a result of purchasing a required component or subscribing to a license. • The solution will be designed for only outdoor use. • The solution is limited to paved roads with no stairs.

Risks and Remedies	
Risk	**Remedy**
Weak wide fidelity (Wi-Fi) signal.	Use 4G network.
A part breaks down.	Replace with higher quality part.
Shipping delay/dead on arrival.	Order them early/Find local alternative.
A team member quits.	Find another, otherwise just keep going with two.
Term concludes sooner than scheduled	work for extra hours, fulfill the musts in worst case scenario.

Table 1 Product Design Specifications

2.7 LITERATURE REVIEW

As engineers, we are tasked to fully study a situation before engaging in any developmental and or design activities. Furthermore, to understand the current technology and innovation of our century we will conduct a literature review on three cases. Undoubtedly, these cases will cover autonomous robots and some of their uses. It should be noted that most of these cases are within the past few years. Which will give us an accurate lookout on the current technologies. On the other hand, we believe these cases might give us inspiration to lead us into some ideas for our problem solution.

Case Study #1: Smart Drone Delivery System [3]

With the ever-growing usage of online shopping and e-markets, the usual petrol operated vehicles that succumb to gravity is not enough to cover the demand that is

skyrocketing. Consequently, the first case study published by Shivaji University in India talks about a smart drone delivery system. In this delivery system, it is proposed that a Quadcopter (QC), which is an Unmanned Aerial Vehicle (UAV), delivers orders requested through online shops autonomously by the use of Google Maps and its own processing unit. The paper also mentions “the QCs capability of delivering parcel ordered by online and coming back to the starting place.”.

The QC’s that will be deployed should have a vertical take-off and landing protocol in order to reduce the area required for functionality. Furthermore, this will allow the QC’s to function in small neighborhoods and streets which many cramped cities have. A 10–15-mile radius can be covered by a single QC. In addition, the vertical approach to these QC’s allows them to carry more payload, this in turn will yield better results for the online shops.

A basic working principle for the QC’s was stated in the paper. A total of four rotary motors at equidistance from each other and a central driver is suggested for a vertical takeoff/landing protocol. To be clear, this configuration functions in a specific way. As such, opposite rotaries spin in opposite directions while adjacent ones function similarly. Using this design, any gyroscopes controlling the QC’s is not needed.

Finally, the methodology for delivering the shipments is as follows; The processing unit of the QC’s, which is a raspberry pi, is interfaced with a camera, video streaming, SD card and GPS. When an order is placed, all these technologies work together to find the

correct address of the house and deliver the shipment. Below is a figure that showcases the order of operations.

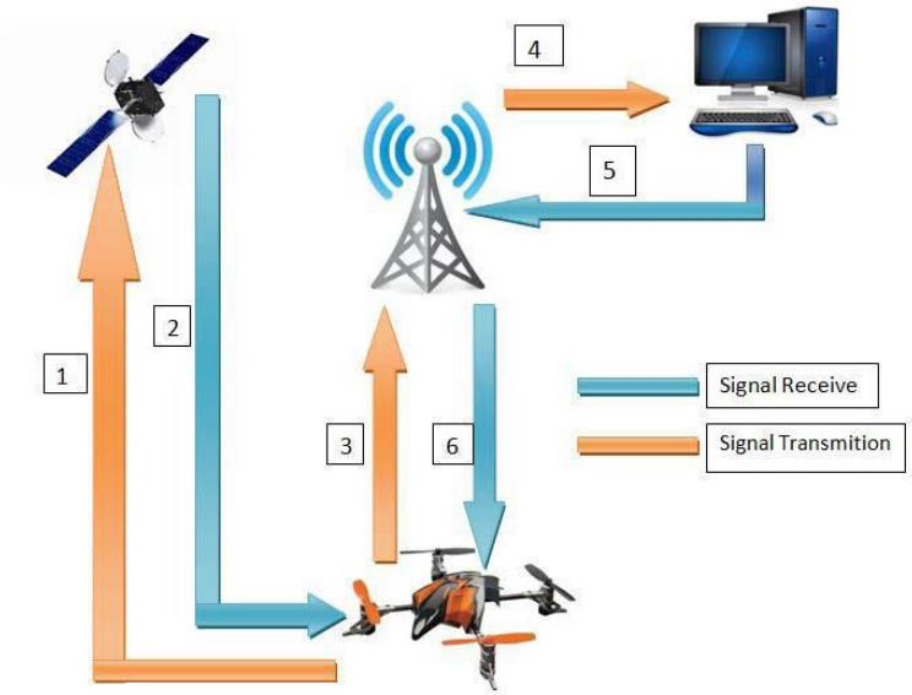

Figure 1 Showcasing the QC commands[3]

Case Study #2: Prototype design of medical round supporting robot "Terapio" [4]

In this case study, the main focus is a robot that is implemented inside an important ecosystem. Terapio is a medical assistant autonomous robot that will revolutionize the healthcare scene. Its main functions are to deliver armamentarium and provide health care data to the doctors. Whether it be a scalpel, a syringe or even a dental kit, this robot can fetch and receive any equipment a doctor need. Furthermore, the robot has the medical history of the patient and can assist the doctor in evaluating a patient's needs. The robot boasts an

internal storage and object detection which can prove to be helpful in navigating the hospital hallways that are clustered with personnel and objects.

Fascinatingly, the robot has three main modes of operation. First, human tracking mode. The robot follows the specified doctor and accompanies him wherever he goes. This mode is useful for the doctor since he does not have to worry about carrying the robot around. Second, Power assisting mode is where the robot can hold the patient, hold a tool or even detect force specified by the doctor. To explain, a dentist might need a tool to be held in a specific way to access a wisdom tooth. The robot can hold the tool precisely and accurately. This in turn can reduce the burden on the dentist and allow him to complete the surgery effectively. Finally, the round mode is an interesting mode. The robot listens to the consultation and records it. Furthermore, the robot denotes everything and organizes it for the doctor for later use. An extra feature of the robot is its facial expressions. These facial expressions help reduce the emotionlessness of the robot which in turn can increase the healing of patients via emotions. Below is a figure representing the modes of Terapio

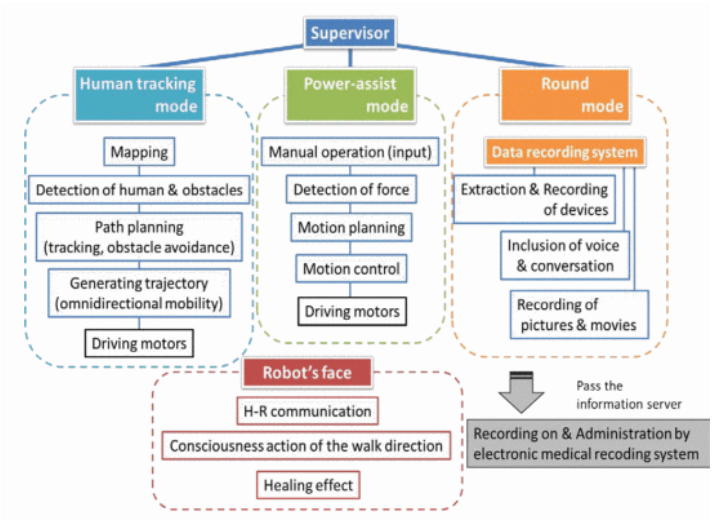

Figure 2 Showcasing Terapios functions[4]

Case Study#3: Design and Development of Autonomous Delivery Robot [5]

This research published by Visvesvaraya National Institute of Technology discusses the design of an autonomous delivery robot with some limitations. This project is capable of

carrying a maximum weight of 2kg this low-bar line is due to the use of low torque motors. To carry higher weights the use of higher torque motors is essential. On the other hand, the motors used have 300rpm which increases the ability of moving the robot much faster ensuring it is within the road speed limits. For the main board the project uses Nvidia Jetson TX1 for controlling and running global and local planning algorithms. It also uses an Arduino Mega to control the motors and manage the sensors' readings. The two boards communicate using rosserial to publish the sensors' readings and to receive the moving commands controlling the motors. The design uses multiple components to provide very accurate localization and obstacles avoidance, one main component used is a RGBD camera which is used to get the front view with a 3D depth map in addition to a laser range finder which gives a 2D depth map. Another component used for an accurate localization of the robot and for the purpose of determining the orientation of the robot is the inertial measurement unit (IMU) which includes an accelerometer, a gyroscope and magnetometer for a better estimate of the position. To avoid collision, an IR sensor with a range of 4-30 cm is used as the last option to save the robot from collision.

For this project, a map-based localization approach is implemented. Which leads to some potential problems that could be a result of the accumulative errors of the used sensors (e.g., the GPS could produce a 10 meters error in some cases), For this reason the paper suggests the use of statistical filters for more accurate localization. The paper discusses another essential topic for navigating an autonomous robot which is the use of high-definition maps or simply ADAS maps, which could lead to an accuracy of 10 cm. Although the project did not use SLAM (Simultaneous Localization and Mapping), but the paper suggests the use of SLAM as a solution to improve the accuracy of mapping localization of the robot. The paper also discusses the used algorithm for path finding, in this case it is the A-star algorithm. Although it is not the best algorithm in finding the shortest path, but the researcher justifies that the project needs a fast algorithm more than an accurate but slow

one to avoid getting stuck. however, the researcher suggests further research to be carried out for the optimization of the grid generation.

Case Study #4: a Raspberry pi Delivery Robot Controlled by Live Stream Chat [6]

Droiid is a delivery robot created by Even Kouao a youtuber and a software engineer at Vodafone. Droiid is a delivery robot controlled through the commands sent on a live stream chat on Twitch. Unlike other robots, Droiid has six wheels instead of four this could make its movement smoother than other four wheels robots. The outer design of the robot is a custom 3D printed design to ensure it is not very heavy. However, the downside is it may not survive under strong circumstances. Droiid is not fully autonomous as it still needs to receive its commands from the live stream chat. The robot has two main features, Speech, and movement in both cases the commands are received from the live chat. Which convert the text message received form the Droiid server to a speech sent to the output speaker.

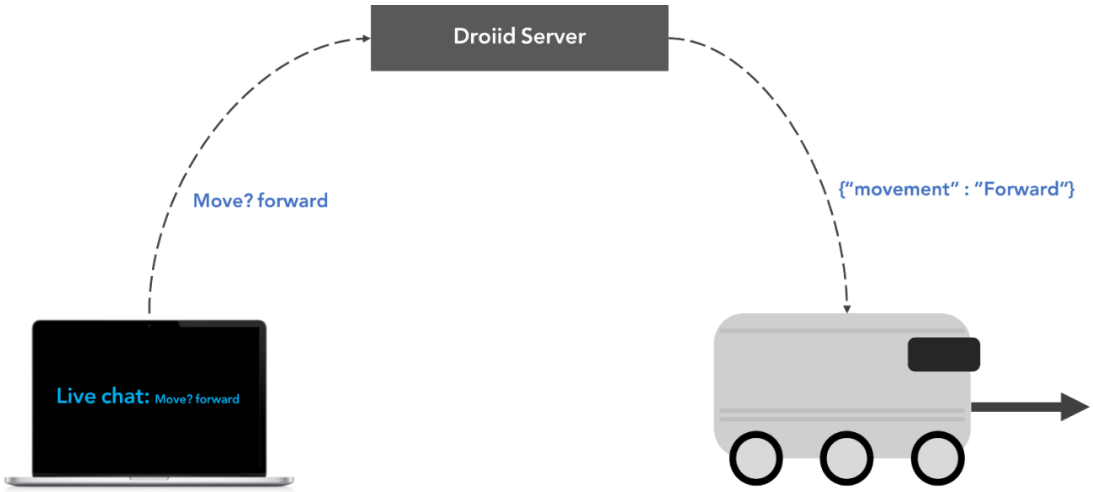

Figure 3 Droiid movement and commands[5]

2.8 THEORETICAL BACKGROUND AND ANALYSIS

Actuators:

Actuators are simply motors; they are used to convert one shape of energy to a mechanical energy. The mechanical energy produced or simply the motion could be in linear or rotary motion. As the names suggests linear actuators responsible of producing the linear movements. While the rotary actuators are responsible of rotary motions through a circular path. There are three main measurements associated with actuator we will discuss, as follows:

A) Torque

The torque is a measurement of how much rotational force this actuator can produce. There two commonly used measurement units for torque, one is the newton meters (N.m) which is physically defined as the torque produced by a one-newton perpendicular force applied to a one meter long arm. Another unit used is the (Kg-cm) which is defined as the torque required for holding a 1 Kg mass at a radical distance of 1 cm. generally, the higher the torque is describes the higher abilities of the motor to push, pull or move heavier objects.

B) Speed

The speed of the actuator is defined as the rotation rate of the motors. A common unit to measure the speed of an actuator is by using the counts of revolutions per minutes known as (RPM). The speed of the actuator is highly dependent on the carried load's weight, a very high weight reduces the actuator speed. However, It is known that the speed measurement is done one the actuator when no load is carried. [7]

C) Energy efficiency

Energy efficiency is one of the main concerns of any engineering tool. For actuators, it is basically a measurement of the amount of the used energy to perform a certain. The lesser amount of energy used to perform the same task is better than a higher amount with same mechanical performance.

As discussed above, actuators can be classified into categories based on certain set of classification criteria. However, we will discuss some commonly used actuators especially in the robotics field, they are as follows:

1) Brushless DC Motor

Brushless DC motors are considered to be of the highly efficient motors in producing higher torque. As **Fig.1** shows, the brushless motor is simply a DC motor with no brushes. It has a permeant magnet. This permeant magnet called Rotor, as it rotates through the changes in the magnetic field around it caused by the coils known as stators. In order to control the rotation, we simply have to control flow and the direction of the current passing through these coils.

A brushless DC motor, as the one shown in **Fig.1** uses three coils for each coil to wires are required for the flow of the current through that wire. Thus, for the brushless DC motor with only three wires it requires six wires. But, usually in many

brushless DC motors it is designed that three of those six wires are internally connected. And we simply have the other three motors.[8][9]

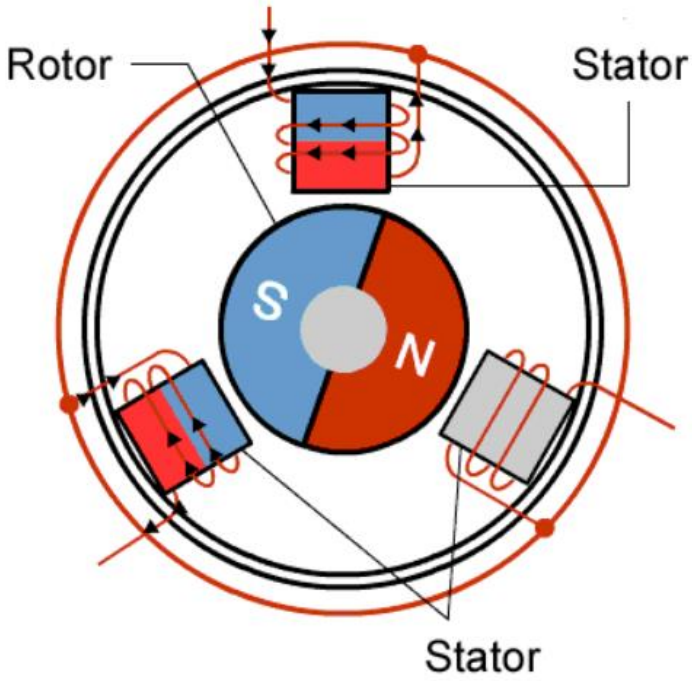

Figure 4 - Brushless DC motor internal connection [9]

2) Brushed DC Motor

In the Brushed DC motor, instead of a rotary magnet we have a fixed permanent magnet it is called stator. The Coils rotates instead of the magnet through the current flowing through what we call brush. **Fig.2** shows a brushed DC motor, note that the permanent magnet is fixed while the coils are the rotatory part resulted from the current flow through the brush.

Brushed DC motor not only has a simpler design, it also easier to control using the current flow that passes through the brush to create magnetic field causing the coils to rotary as a result of the force produce by the magnetic field between the permanent magnetic and the coils on the rotor. [9]

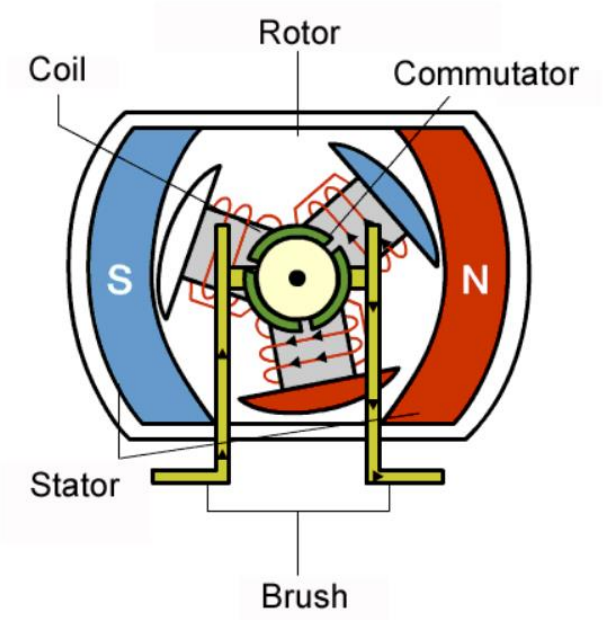

Figure 5 - Brushed DC motor internal connections [9]

3) Servomotor

Servomotors are commonly used in robotics field. It provides a control of the angular position through controlling a motor with an internal controller and feedback position. There are different types of the servomotors, one frequently used type is a servomotor with maximum shaft rotation of 180^{o}. This rotation is powerful in robotics applications as it could be used for pulling, pushing or rotation actions. **Fig.3** shows the internal diagram of a servomotor.

Although we discussed the 180^{o} rotation only, there are another type of the servomotors called a 360^{o} continuous rotation servomotor used for applications where a full rotation is required. It is similar to the regular servomotor we discussed above but the shaft used here can spins continuously instead for the narrower range.[10]

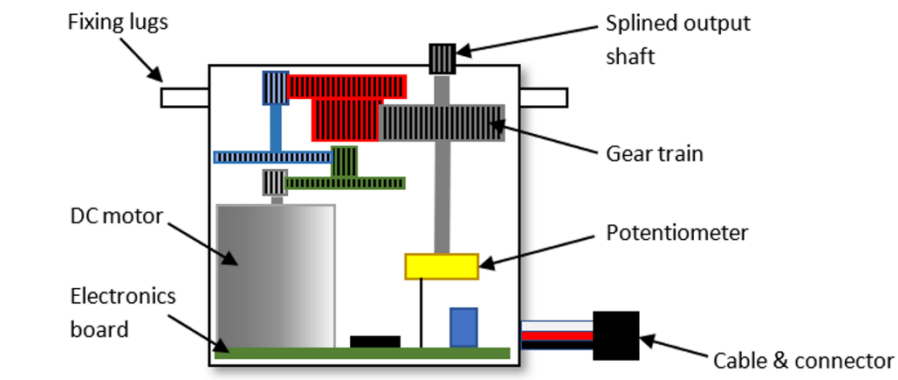

Figure 6 servomotor with its internal components [10]

Power Electronics Circuits:

We have already discussed the actuators but one thing to be mentioned is the actuators has specific voltage and current requirement. Also, driving those actuators require specific electronic circuits. In this section, we will discuss some commonly used power electronic circuits, as follows:

1) H-Bridge

As we have discussed, the DC motors can rotate in two directions. If the motor plus pin connect to the V_{cc} and the minus was grounded it will spin differently than if we reversed the connections. one way to control the spinning direction without the need to plug and unplug the pins is done using H-Bridge. An H-bridge circuits shown in **Fig.4**, allows the current to flow in both directions by controlling the switches shown in the figure.

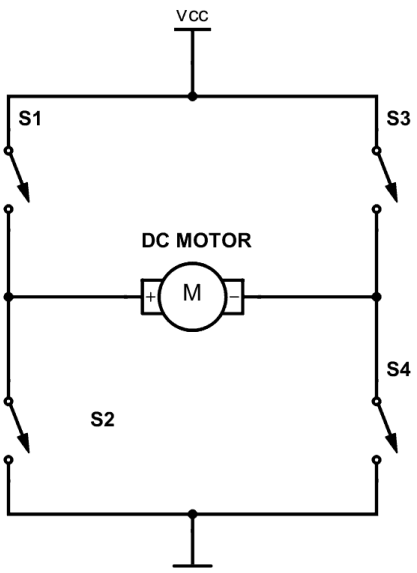

Figure 7 - H-Bridge internal connection [11]

To control the spinning direction of the motor we can close the switches s1 and s4 so the current flows from V_{cc} through s1 passing through the motor toward the ground. The current flow path is shown in **Fig.5a**. This will make the motor rotate in a certain direction.

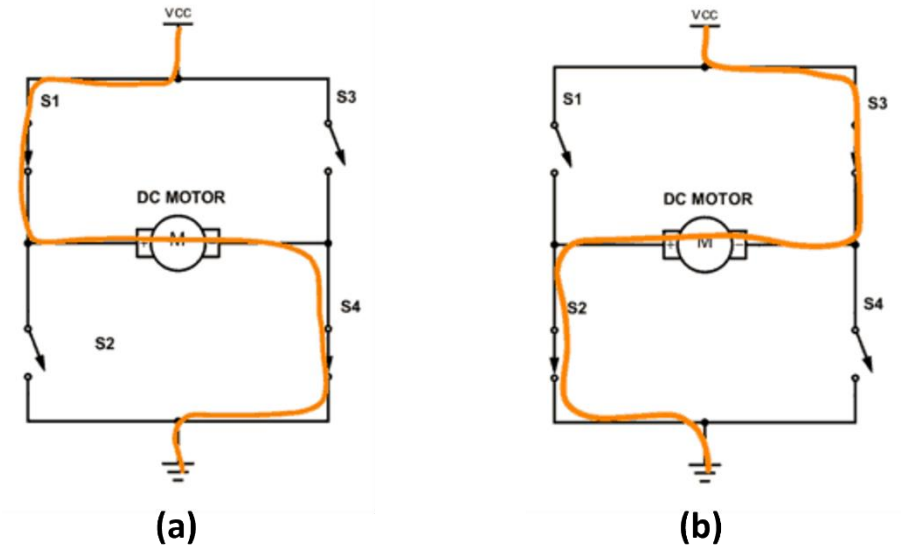

Figure 8 - (a) the current flow path when s1 and s4 are closed (b) the current flow path when s2 and s3 are closed [11]

To make the motors spins to the other direction, we can close the switches s2 and s3 to force the current flow through from the minus pin of the motor to the positive pin making the motor spinning in the opposite direction. **Fig.5b** shows the current flow when s2 and s3 are closed. [11]

2) DC Motor Driver

The H-Bridge circuit discussed above will take a part in the design of the motor driver. **Fig.6** shows a simple implementation of the motor driver for illustration purposes with its internal connections. From the figure, we notice the H-bridge is works exactly as discussed above. The switches shown in the figure for sure are not mechanical switches. In many implementations, the switches used are transistor that are able to

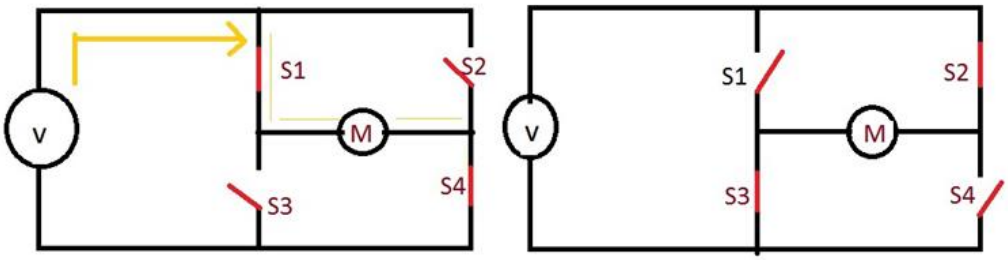

Figure 9 – A simple implementation of a motor driver [12]

handle enough current and have a low V_j to reduce the drop in the voltage between the collector and emitter of the transistor.

The implementation show in **Fig.7** is used for three phase brushless DC motor. When a 120^o positive current is supplied then the motor spins in the counter-clockwise direction. There are other motor driver implementation as the one shown in **Fig.8** is a single phase brushless DC motor driver.[12]

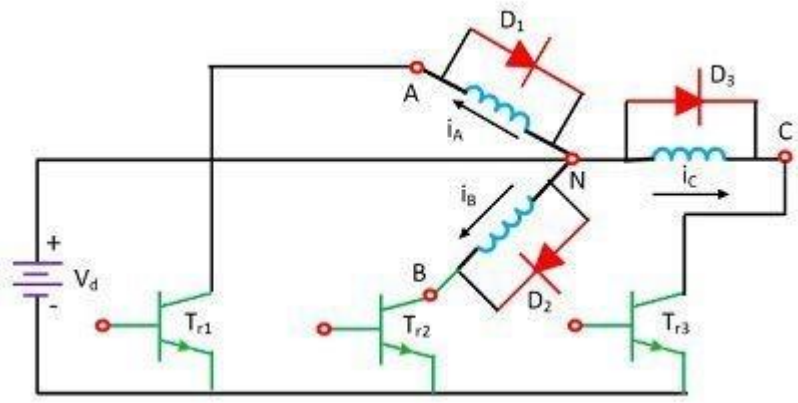

Figure 10 - Three Phase Brushless DC motor drive [12]

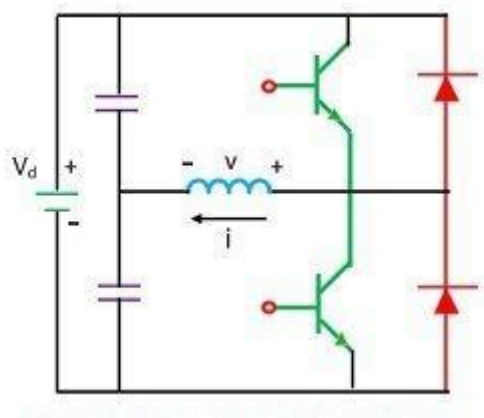

Figure 11 - Single phase brushless DC motor driver circuit [12]

3) DC to DC convertor

A DC-to-DC convertor is used to convert the source voltage level to another specified voltage level. In short, it takes the voltage coming from the input pins and output a lower or higher voltage level based on the design requirements. Both input and output signals are DC. **Fig.9** shows the principle of the DC-to-DC convertor.

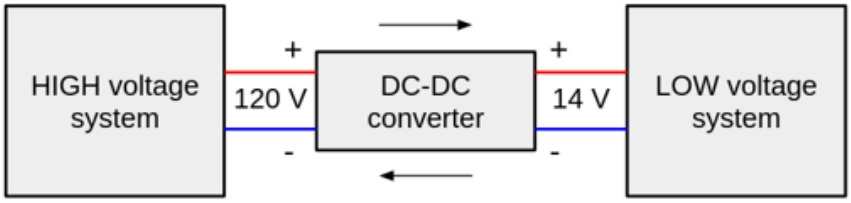

Figure 12 - The principal block diagram of the DC-to-DC convertor [13]

There are multiple implementations of the DC-to-DC convertor circuit. However, for illustration we used an implementation shown in **Fig.10** for the DC-to-DC convertor. This implementation is based on switching frequency of the switch S.[13]

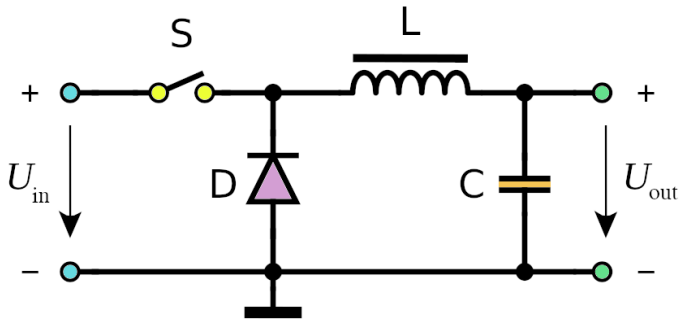

Figure 13 – A switching DC-to-DC convertor [13]

Sensors:

Sensors are an important part of any robot; they can retrieve information that is easily accessible to us humans. Temperature, distance, oxygen levels to name a few are converted into an electrical reading that can be processed by the brains of the robot. Furthermore, they can be used as a way to give important parameters to a robot in order to function properly. Below you will find a few sensors that could be used to further enhance our project idea.

1-LIDAR sensor

Light Detection and Ranging is a very interesting remote sensor that measures the exact distance of an object. The LIDAR sensor uses a pulsing technique where it pulses light to determine the exact location of whatever the sensor is aimed at. Since the LIDAR technology uses light, we can calculate the distance by the following formula:

$$D = \frac{C * T}{2}$$

Where "D" is the distance of the object, C is the speed of light (299,792,458 m/s) and T is the time it takes to return to the LIDAR source.[14][15]

Figure 14 Showcasing a LIDAR sensor [15]

2-Ultrasonic sensor

Ultrasonic sensor is a very interesting sensor that shoots ultrasonic waves to calculate the distance. Much like the LIDAR sensor, it waits for the waves to return back and from there we can calculate the distance. Furthermore, it uses a transducer to send and receive high frequency pulses to determine the location. The equation below is used with the specific model HC-SR04

$$D = \frac{S * T}{2}$$

Where D is the distance, S is the speed of sound (340m/s) and T is the time.[16][17]

Figure 15 Showcasing an Ultrasonic Sensor [17]

3-IR sensor

These sensors work by emitting and receiving infrared radiation. The radiation hits objects nearby while the receiver waits for the bounce-back of the signal. It can detect movement and distance of the object. There are three types of infrared ranges;

- Near-infrared - from 0.75 to 3 3µm
- Mid-infrared - from 3 to 6µm
- Far-infrared - higher than 6µm[18][19]

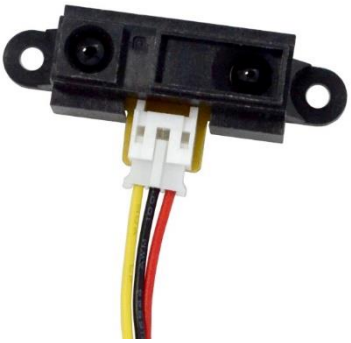

Figure 16 Showcasing the IR sensor [19]

Controllers

Perhaps one of the most important parts of the robot is the controller. Which is the brain of the system. Granted, to be able to fully utilize the controller, sensors and actuators are also needed. Controllers are able to interface the sensors with the actuators. Which allows us to control the outputs of the actuators based on inputs of the sensors. Controllers vary in complexity, efficiency, and ease of use.

1-Arduino

Arduino boards are one of the most popular boards in DIY projects used by both hobbyists and professionals. An Arduino board is a microcontroller board containing many different things including RAM, IO ports, and the microcontroller itself. There are different types of Arduino boards that differ in both size and capabilities. The most popular type might be the Arduino uno which is based on the ATmega328P microcontroller. Arduino boards also contains a part of the integrated development enviroment (IDE) that is used to program it. The Arduino IDE uses a basic version of C++. [20][21]

Figure 17 - Arduino uno board [21]

2-Raspberry Pi

Raspberry Pi is called a single board computer (SBC) it functions basically like a full computer, an operatic system can be installed on it and the user can connect a monitor, mouse and keyboard to it. Raspberry Pi(s) are Linux based computers although different a different operating system like android can be installed on it. A Raspberry Pi has a clock speed that is much higher than even an Arduino mega (1.2 GHz vs 16 MHz). [22][23]

Figure 15 - Raspberry Pi 4 [23]

2.9 ANALYZING ALTERNATIVE SOLUTIONS

2.9.1-Morphological chart

Function	**Means**				
	1	**2**	**3**	**4**	**5**
1. Traversal of the campus	Wheels	Propellers	Continuous wheel track	Quadruped/Biped	Conveyer belt
2. Carrying the package	Wagon	Carried Box	Pneumatic tubes		
3. Navigation	GPS	Predefined path	Pilotage [i]		
4. Maintain the safety of the package	Digital lock	Combination Lock	2-step verification		
Feature	**Means**				
	1	**2**	**3**	**4**	**5**
1. Fast	Motors power	Mechanic	Lightweight		
2. Long battery life	Energy consumption	Capacity	Recharge time		

Table 2 Morphological Chart

[i] navigating by reference to visible landmarks

- **Alterative A:** Quadruped robot with a wagon attached to it, navigates using pilotage, the packages are secured using a 2-step verification system (2FA)
- **Alternative B**: Conveyer belt where the packages are put in a plastic box and placed on it, the conveyer belt spans the campus on a predefined path, the packages are secured using a combination lock.
- **Alternative C**: Ground robot that uses wheels to traverse the campus, the package is loaded on the robot (carried box), it navigates using GPS, the packages are secured using a Digital lock

Ideas from initial brainstorming:

- **Alternative D:** Robot Train
- **Alternative E:** Pneumatic System
- **Alternative F:** Drone delivery

Alternative analysis

Ground Robot

A ground robot with a built-in storage cart uses four wheels to move between buildings within the university campus. The robot needs to be able move safely using obstacle avoidance techniques to avoid objects around it. It uses battery, to supply enough power for a complete back and forth trip. To be able to move between buildings, the ground robot needs a navigation algorithm to guide the robot through the whole trip.

Pros:

- Dynamic stop points
- Flexible pathfinding
- Doesn't require special roads
- Moderate complexity

Cons:

- Requires obstacle avoidance algorithms
- Higher probability of getting stuck
- Easily tampered with
- Training phase is required

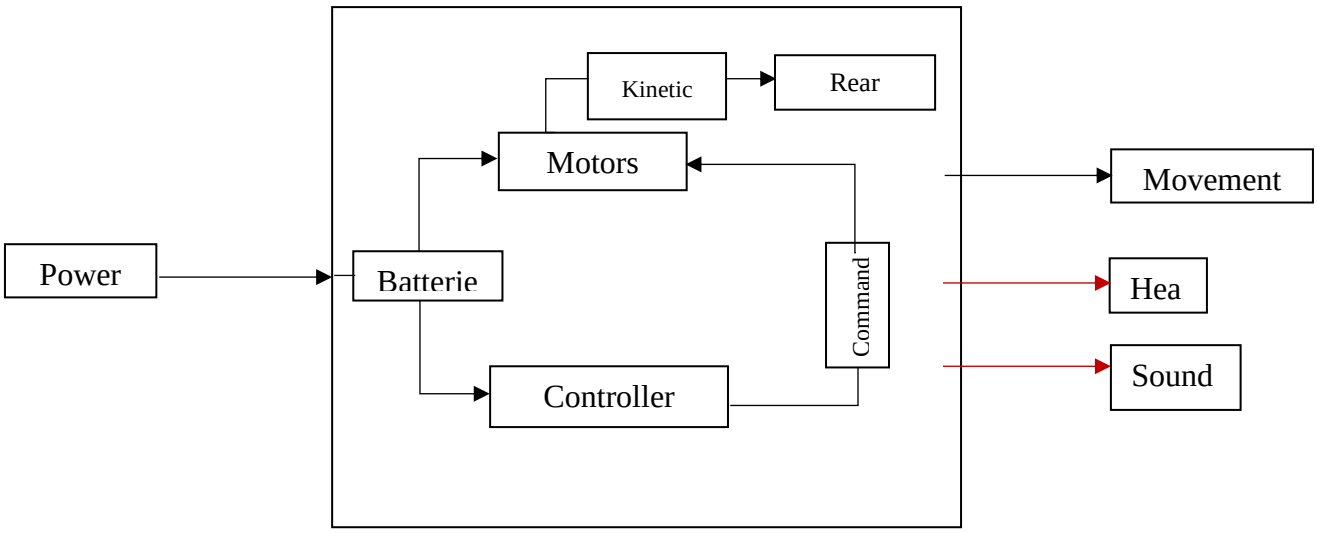

Figure 18 – Ground robot Glass box

Cost analysis

ITEM	Expected Price	Quantity	Total
Jetson nano	$75.00	1	$75.00
Stereo Camera Module Compatible with Jetson Nano	$45.00	1	$45.00
Motor driver	$12.00	4	$48.00
Platform	$100.00	1	$100.00
Battery	$20.00	1	$20.00
Wheels	$12.00	4	$48.00
Motors	$15.00	4	$60.00
Total cost			$336.00

Table 3 Cost analysis for ground robot

RoboDog

This alternative is a quadruped robot. It uses two front legs and two hind legs to move just like an animal would. Furthermore, it can traverse at acceptable speeds and carry a heavy load. This alternative can also walk on the campus and roads.

Pros:

1- Innovative
2- Can climb stairs
3- Can drag or carry the packages

Cons:

1- Complex
1- Easily tampered with (pushing, vandalizing, etc…).

ITEM	Expected Price	Quantity	Total
Jetson nano	$75.00	1	$75.00
Stereo Camera Module Compatible with Jetson Nano	$45.00	1	$45.00
LIDAR sensor	$100.00	1	$100.00
Gyroscope sensor	$15.00	1	$15.00
Wagon	$60.00	1	$60.00
Battery	$20.00	1	$20.00
Artificial limbs (3D printed)	$40.00	2	$80.00
Servo motors	$20.00	8	$160.00
Total cost			$555.00

Table 4 Cost analysis for robodog

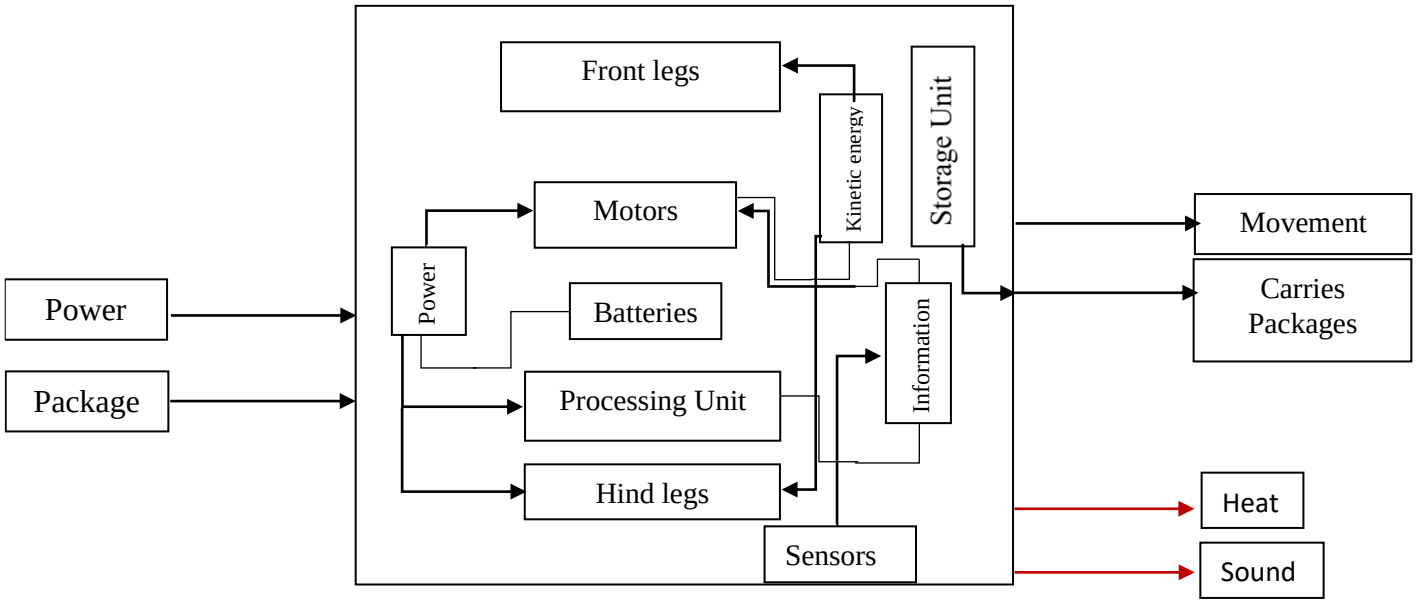

Figure 6– RoboDog's Glass box

1. Robot train tracks

To be able to use a mini train within campus, we need train tracks that connect the buildings we want to deliver to and from. By having different stops at different faculty buildings, and smart train junctions that can save time by switching to shorter routes the user can drop off the packages at 1 of the stops and then the receiver would take the package at the stop nearest to him/her.

Pros

- Eliminates the need for navigation algorithms.
- If pedestrians avoid the tracks, no need for obstacle avoidance.
- Can be fast

Cons

- Requires train tracks to function.
- Sub-optimal routes
- Limited to set of stops

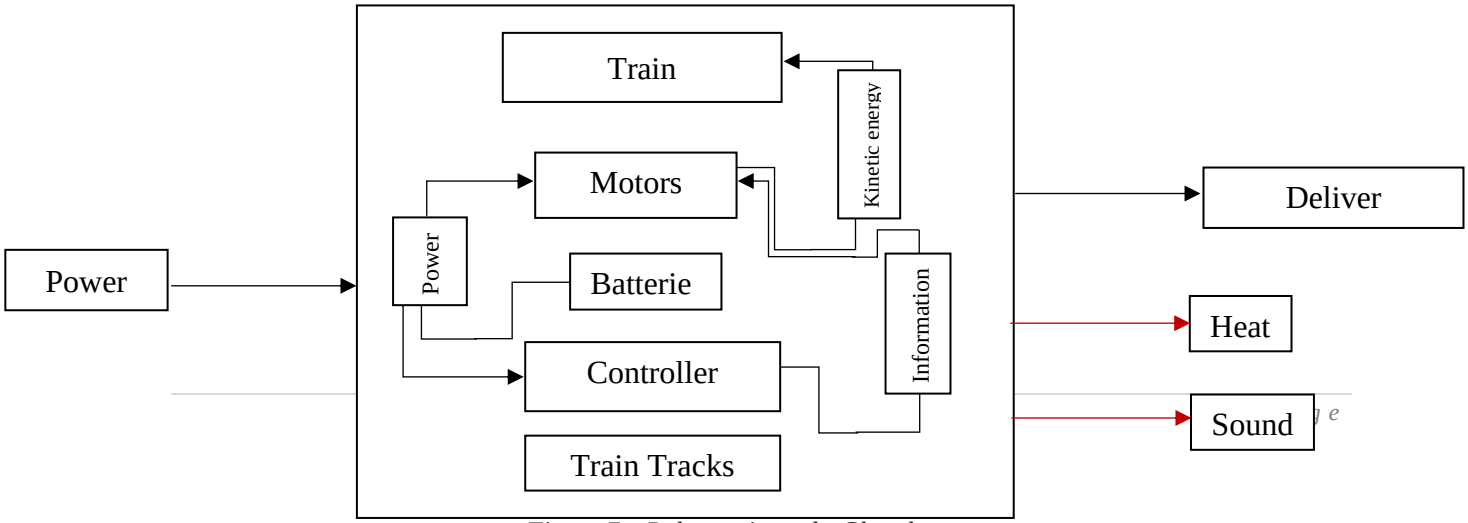

Figure 7 – Robot traintracks Glass box

Cost analysis

ITEM	Expected Price	Quantity	Total
Arduino uno	$40.00	1	$40.00
Wagon	$60.00	3	$180.00
Battery	$20.00	1	$20.00
Traction motor	$450.00	1	$450.00
Total cost			$690.00

Table 5 robot train cost analysis

Choosing Baseline Design

Musts/Alternatives	A: Quadruped Robot	B: Conveyer Belt	C: Ground Robot	D: Robot Train	E: Pneumatic tube system	F: Drone
The ability to move within 2 km range of the Engineering building	GO		GO	GO		
Ensures the safety of the packages.	GO	GO	GO	GO	GO	GO
Includes a storage unit for the shipments.	GO	GO	GO	GO	GO	GO
Tamper proof electronic components	GO	GO	GO	GO	GO	GO
Made from durable material.	GO	GO	GO	GO	GO	GO
Operate within 5 km/h.	GO	NO GO	GO	GO	GO	GO
Can carry weight within (80kg).	GO		GO	GO	NO GO	NO GO
Constraints						
The cost of the project must not exceed 5000 SAR.	GO		GO	GO		
Project must be completed before the end of Term-2.	GO		GO	GO		
Causes no harm to the surroundings.	GO		GO	GO		
Battery life lasts for at least one complete trip (2 km).	GO		GO	GO		
Guarantees the privacy of the packages.	GO		GO	GO		
The artifact should withstand normal heat (36° C) for the duration of the trip (2 km)	GO		GO	GO		

Table 6 KTDA table

After analyzing the alternatives, we chose the **Ground Robot** to be our baseline design. Due to it having the lowest cost, balanced complexity, and the availability of the parts. We modeled our idea using SolidWorks to be able to imagine our baseline design.

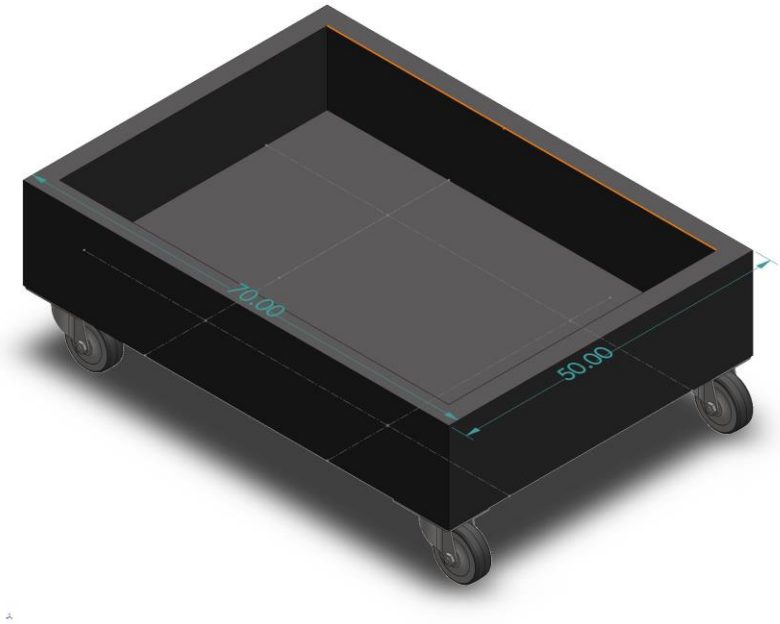

Figure 19 Solidworks model

2.10 MATURING BASELINE DESIGN

To further improve our base model, we started thinking of things we could change. We thought of reusing a hoverboard instead of buying the different motors and motor drivers. Hoverboards contain powerful motors that could carry people (~100 kg) which makes the design sturdier. Furthermore, wheel encoders are included in the hoverboard eliminating the need to buy them. In addition to that, the hoverboards have a recharging capability that is simple to use. We also thought of adding ventilation slits to the wagon to improve thermal dissipation. In addition to that, one idea was to add a hole in the wagon for cable management to eliminate the possibility of unwanted friction of the wires with the ground.

CHAPTER – 3 PRODUCT BASELINE DESIGN

3.1 BLOCK DIAGRAM

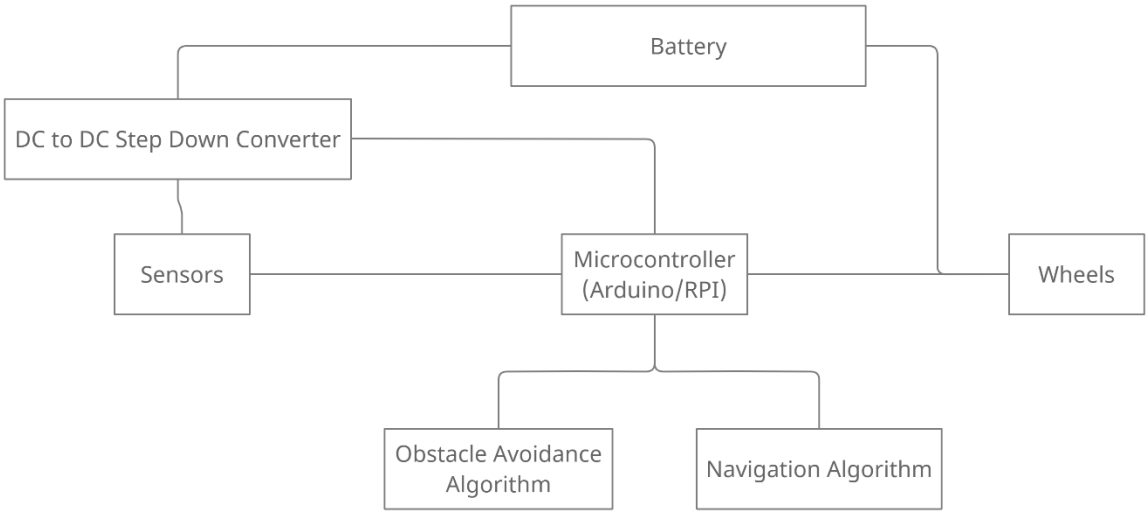

Figure 20 Block Diagram

3.2 SYSTEM DESCRITPION

3.2.1 Circuit schematics

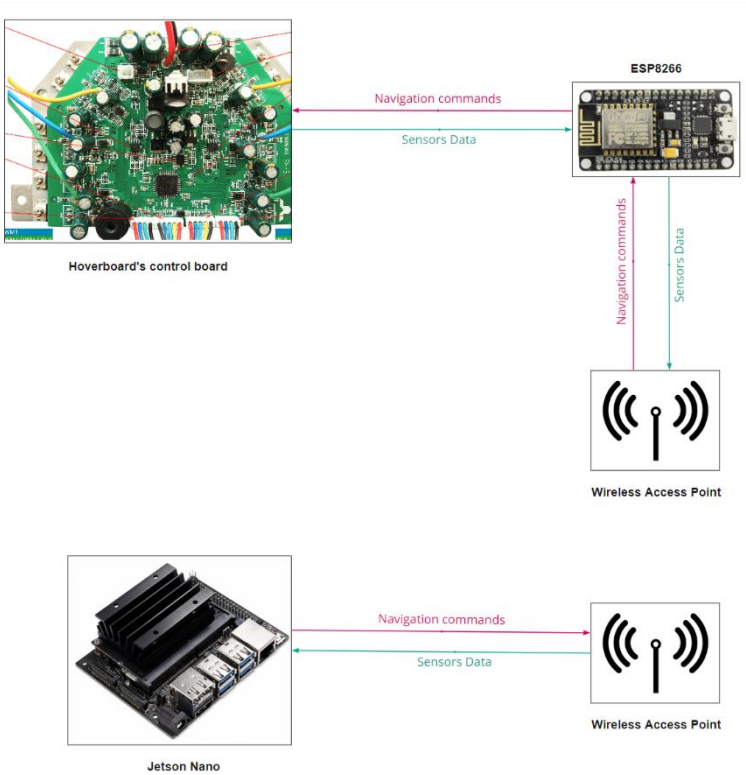

Figure 21 Circuit Schematics

The green arrows represent the flow of data from the sensors. As shown in the figure the sensors data flow from the hoverboard to a Wi-Fi module and then to the Jetson Nano. The data is then processed by the Jetson nano and using the algorithms for navigation and obstacle avoidance it sends the commands though the chain to the hoverboard

3.2.2 Circuit component specifications

Component	Specifications
Jetson Nano	**Manufacturer:** Nvidia **GPU:** 128-core NVIDIA Maxwell **CPU:** Quad-core ARM® A57 **Memory:** 2 GB 64-bit **Module Size:** 70mm x 45mm
NodeMCU ESP8266	**Microcontroller:** ESP-8266 32-bit **Module Size:** 49mm x 26mm **Clock speed:** 80 MHz **Operating Voltage:** 3.3V **Input voltage:** 4.5V-10V **SRAM:** 4 MB / 64 KB **Digital Pins:** 11 **Analog Pins:** 1 **Built-in Wi-Fi:** 802.11 b/g/n **Temperature range:** -40C - 125C
IMX219-83 8MP 3D Stereo Camera Module	**Megapixels:** 8 Megapixels **Resolution:** 3280 × 2464 (per camera) **Dimensions:** 24mm × 85mm **Gyroscope Operating Current:** 1.23mA **Angle of View:** 83/73/50 degree (diagonal/horizontal/vertical)
dc-to-dc convertor 12v to 5v	**Manufacturer:** Chuanguifa **Type:** step down dc-to-dc convertor **Input voltage:** 12V **Output Voltage:** 5V **Output current:**3A **Output power:**15W **Efficiency:** ＞96% **Operating temperature:** (-40°, 80°) **Size:** 45x26x12 (mm)
Rechargeable battery	**Voltage:** 36 V **Discharge Current:** 75A **Dimensions:** 101mm x 90mm x 70mm **Weight:** 1.62 Kg **Internal Resistance at 1KHz:** 34 mΩ
Motors	**Manufacturer:** huhu **Speed:** 100 RPM **Operating voltage:** 36 volts **Torque:** 10 Kg.cm **Weight:** 158.75 g

Table 7 Circuit specifications

3.2.3 Flowcharts for software blocks

Navigation Flow Chart

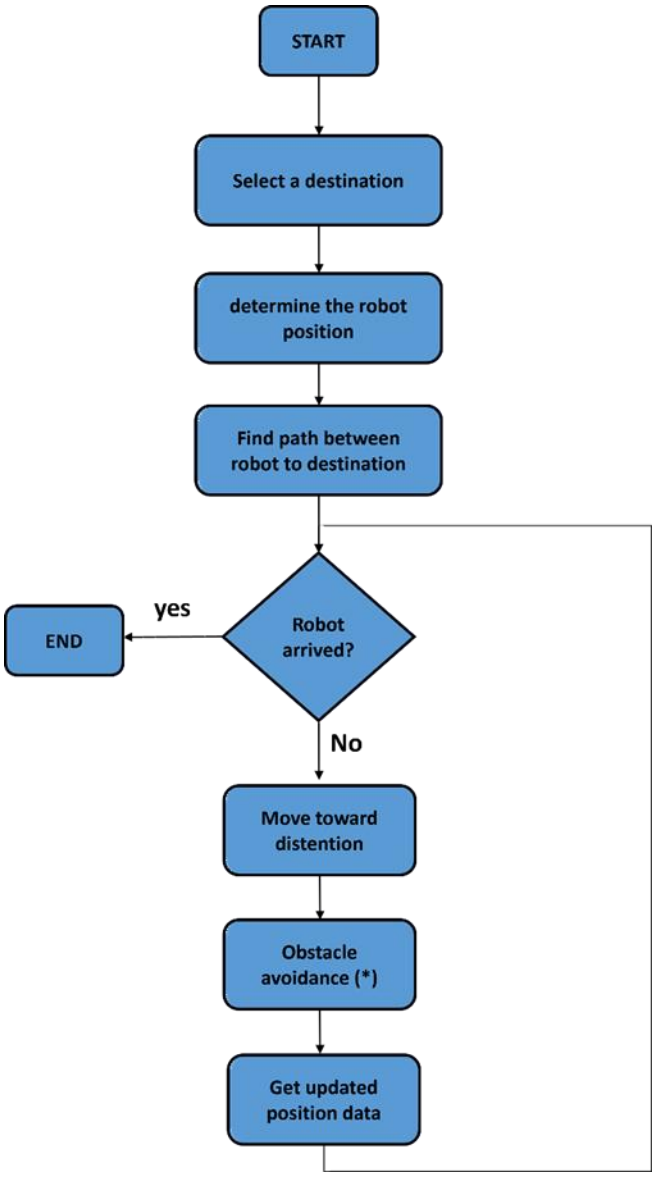

Figure 22 Navigation flowchart

Obstacle avoidance flow chart

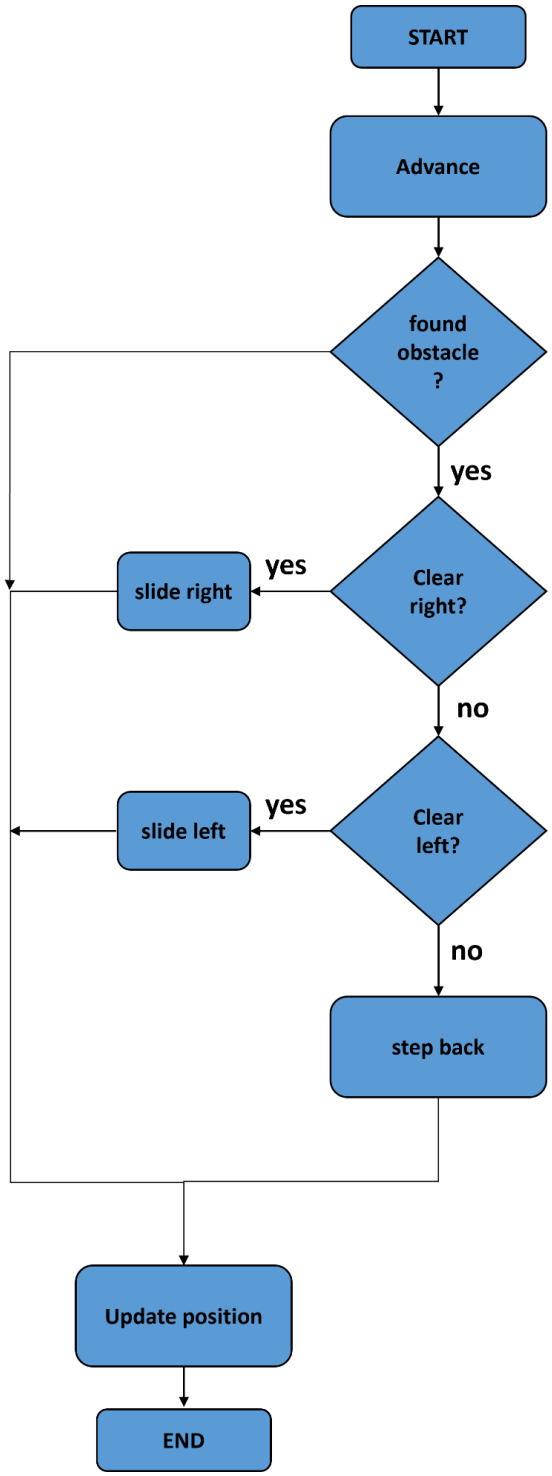

Figure 23 Obstacle avoidance flowchart

3.2.4 Mechanical specifications of the case

The figure below shows a SolidWorks model of the cart after adding the changes discussed in maturing the baseline design. The cart is a rectangular prism with the dimensions (L×W×H) (70×50×20 cm)

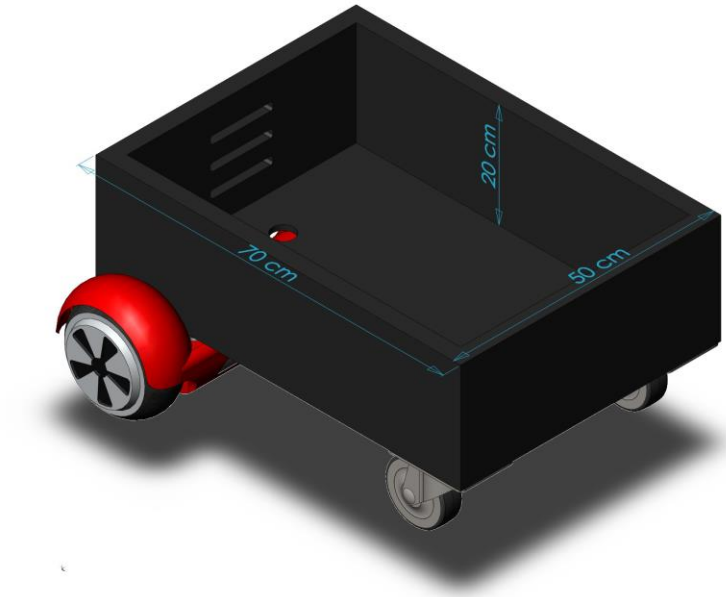

Figure 24 Solidworks model with hoverboard

3.2.5 Possible aesthetics

Aesthetics are an important part to make the user feel more connected to the robot. There are two main aesthetical changes that would be beautiful if applied to the artifact. First, stickers that can be applied to the robot with the logo of KAU and Engineering Faculty. These stickers can be applied to the sides of the platform to showcase that the robot is from the students of the faculty. This in turn may help the users feel a sense of home.

Another beautification idea is painting the robot white in color. This can allow the robot to be seen clearly from far away which can help people recognize the robot. Even though the robot might not need this, it helps promote a beauty aspect in robots.

Figure 25 KAU Icons

3.2.6 Input/output specifications

An AC input power source of 220Vac with 60Hz frequency, single phase is needed to supply the battery with charging power. Max input current is 2A current with max power consumption of 440W.

3.2.7 Operating Instructions

Operation of the robot is very simple; any layman can use it without issue.

1- Locate the robot within a stop point.
2- Place shipment/package inside the luggage compartment.
3- Open the robot UI using any smart device.
4- Enter destination for the shipment and receiver details.
5- Enter lock # for security.
6- Press Start.
7- Wait for confirmation from receiver. (done)

3.3 SIMULATION RESULTS

For simulation we made a localization program using MATLAB. We connected the Arduino to MATLAB, and we used ultrasonic sensors to measure distance and find out the location of the robot relative to the "walls" or in our case, the box's boundaries.

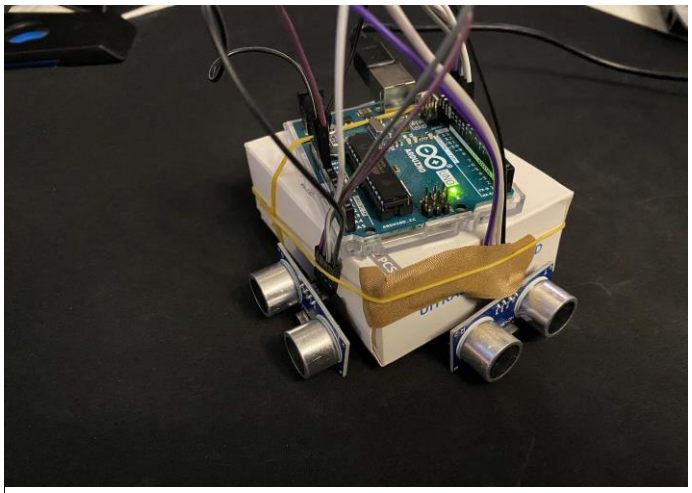

Figure 26 – Localization prototype

The prototype uses 2 ultrasonic sensors 1 for each coordinate in the xy-plane.

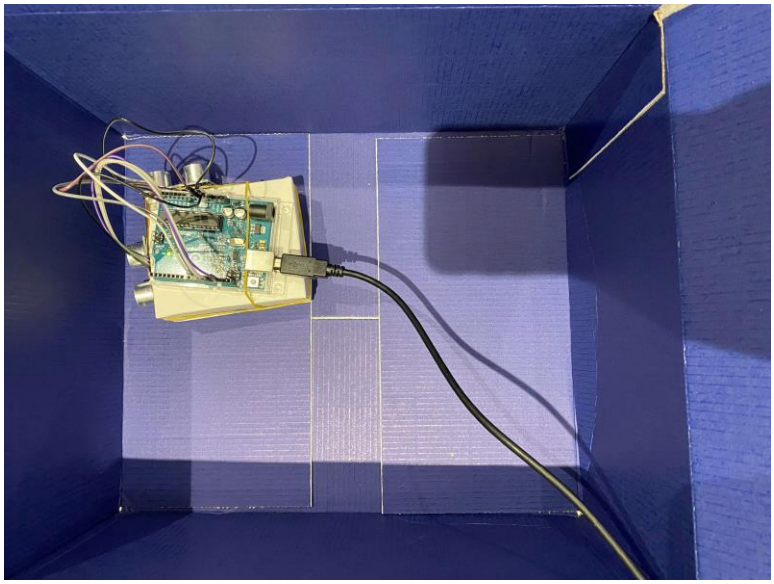

Figure 28 Box used in localization simulation

We placed the prototype in a box and started the program. Giving us the result shown in the figure below.

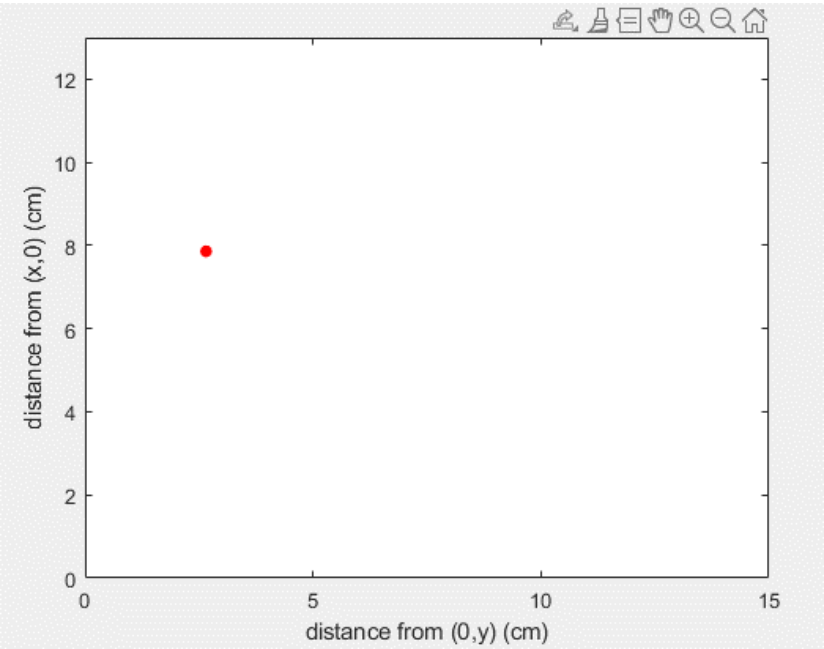

Figure 29 Resultant MATLAB plot showing location

The red dot represents the prototype, and the boundaries of the plot represent the walls of the box. The plot is dynamic, meaning that the red dot moves with the movement of the prototype. It is not just a snapshot of the location at a particular moment.

CHAPTER – 4 PRELIMINARY EVALUATION OF BASELINE DESIGN

4.1 TECHNICAL ASPECTS

Perhaps the most critical musts for our project are the ability to carry a weight within **80 kg** and that the artifact must be able to operate within **5 km/h**. To be able to satisfy those conditions we need powerful motors. Different hoverboards might have slightly different specifications but generally, the motors have a power of about **350 W** at **36 V** and can speed at speeds of up to **700 rpm** at higher voltages. For the speed requirement, hoverboards can operate at about **9.6 km/h** to **16 km/h** in faster models which is more than enough in our case. The wheels used in hoverboards have a diameter of about **15-25 cm**. [24]

4.2 COST ANALYSIS

ITEM	Expected Price	Quantity	Total
Jetson nano	$75.00	1	$75.00
Stereo Camera Module Compatible with Jetson Nano	$45.00	1	$45.00
motor driver	$12.00	2	$24.00
Platform	$100.00	1	$100.00
battery	$20.00	1	$20.00
Wheels	$12.00	4	$48.00
Motors	$25.00	2	$50.00
Arduino uno	$20.00	1	$25.00
GPS	$27.00	1	$27.00
Wifi adapter	$5.00	1	$5.00
Total cost			$419.00

Table 8 Updated cost analysis

4.3 ENVIRONMENTAL IMPACT

It is known for years that our vehicles produce harm gases to our environment. However, we cannot refrain from using them. The only thing we can do, is to reduce our usage and to eliminate unnecessary trips. One service our product provides is to reduce the need of using a car in delivering shipments within the campus.

Although our product does not produce green gases, it still has some impacts on the environment. For instance, the baseline design uses a lead acid rechargeable battery which could cause potential threat to people and to the environment if not properly discarded. However, we encourage having a facility that recycles dead batteries to reduce their potential impact on the environment by extract the lead.

In the baseline design, although we could have included other power options that may produce harm gases to our environment we preferred not to, for the sake of our environment. Another way of visualizing the big picture is to consider that the product reduces the need of having duplicated versions of certain things (e.g., textbooks, papers, plastic tools) by allowing these gadgets to be easily transferred from building to another. Which expected to play good for our environment.

4.4 IMPACT ON SOCIETY

Stereo camera

Although using a stereo camera can facilitate obstacle avoidance and navigation, some people might be opposed to it due to privacy concerns. People might be bothered by seeing a robot equipped with a camera roaming around campus thinking that they are being recorded. To mitigate that effect, we could put notes that state that no camera footage would be published anywhere unless necessary by law.

Motors

Motors are crucial in any type of robot that is expected to move. Nevertheless, it might cause some disturbance to students and faculty members due to the noise. Although according to a survey done as a part of a research project, most people are only mildly annoyed by electric scooter noise in comparison to combustion scooters. [25]

4.5 GLOBAL IMPACT

Robotics is a very interesting subject; the ever-growing revolution of robots is rapidly increasing. Technological advancements in engineering, automation, AI and machine learning will revolutionize the capabilities of robots and they will take over tasks that human laborers use to do.

The robotics industry growth will boost the economy and productivity. Furthermore, it will lead to many new jobs that are yet to exist. Consequently, around 20 million manufacturing jobs may be lost by 2030 to robots. However, robots can be much more efficient than humans at these jobs and can provide better outcomes. Moreover, humans can monitor these robots and make sure the job gets done well.

The effects of job losses have a big variance between countries/regions. In lower skilled regions, the robots can cause twice the unemployment rate by taking up many jobs. This in turn can cause economic and social distress where the regions are already under big issues.

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APPENDIX A: ETHICAL CASE STUDY

بسم الله الرحمن الرحيم

King Abdulaziz University - Faculty of Engineering – EE-499

Senior Design Project
Report#3
Ethical Case Study

Name	ID
Muhannad Saeed Alghamdi	**1846525**

Contents

Saudi Council Code of Ethics

The engineering profession and the services provided by engineers depends significantly on the progress of civilization and the protection and harnessing of natural resources to serve the community and increase the standard of living. Thus, it becomes necessary for engineers to provide their professional services according to ethical standards and rules observing honesty, truthfulness and perfection.

Since the Saudi Council of Engineers is concerned with and aims to promote the profession of engineering and all that would develop and raise the level of the profession and its practitioners under its law promulgated by the Royal Decree No. 36 on 26/09/1423H, and since its vision is to "sophisticate the profession of engineering and enable engineers and institutions of engineering to reach optimal solutions, to improve performance level, and to encourage creativity and innovation to achieve a prestigious international position," the Council has opined to present these rules to engineers and technicians in various positions to serve as professional rules determining proper professional dealing among themselves and with others to serve society.

Since justice, integrity, honesty, truthfulness, keeping one's word, never exposing secrets, mutual advice, mastery of work, and getting away from hurting others are in their entirety the morals and values advocated by Islam that urges to stick to them and to abide by applying them in everyday life, the Saudi Council of Engineers has taken into account these foundations, principles and values when preparing the rules and ethics governing the practice of the profession. Thus, all engineers should abide by these rules in all their professional practices in accordance with the Engineer Agreement signed in this regard. The General Rules of the Saudi Council Code of Ethics (Code of Ethics, 2021):

Rule One: Every engineer should build her/his professional reputation based on efficiency and proficiency of her/his services, and away from unfair competition with others.
Rule Two: Every engineer should seek to develop her/his personal abilities and efficiency, and should also provide professional development opportunities for engineers and technicians working under his supervision.
Rule Three: Every engineer should be committed to promoting the fundamental values and principles of the ethics of the engineering profession and should plant them within society. Regarding her/his conduct, every engineer should be s in ways that support and enhance the prestige and dignity of the profession and the secretariat of the locally and globally.
Rule Four: Regarding professional issues, Every engineer shall act as a careful agent to the employer, and shall avoid any conflict of interests.
Rule Five: When submitting her/his ideas, views and decisions, every engineer should be keen to be objective and honest and confined to her/his field of expertise and professional experience.
Rule Six: When providing professional services, every engineer seeks to apply the highest standards of safety and environmental protection in order to achieve the public interest of individuals and society.

Introduction

Every engineer could be in a position where a decision must be taken. The different possible decision could have some ethics violations, an engineer must consider the different scenarios and choose the best ethical decision based on the used code of ethics. In this report we will discuss an engineering dilemma with some different possible scenarios, discussing the potential consequences of each scenario and taking the best decision for this engineering dilemma.

Engineering Dilemma

Mohammad works as an industrial engineer in a construction company. The company has a constructional project, where the company decided to find a local contractor. The company formed a team to receive the bids and study the different bid offers. Mohammad was requested to lead the team. However, Mohammad's friend Ahmad who works on the same department with Muhammad and who was not selected in the team hinted to Muhammad that he wants to know the bids details. However, Mohammad ignored those hints until Ahmad asked him directly about the bids details so he can leak it to his brother who works as a contractor in the construction field. Now, Mohammad is in a position where he has to take an action, there are different possible scenarios for the actions Mohammad could take, we will discuss each possible scenario and its possible consequences, there are three main points could affect Mohammad's decision we will consider them in each scenario:

1) Mohammad and Ahmad are friends for more than 10 years.
2) Mohammad knows the details of each bid, as he leads the responsible team.
3) Mohammad is a professional engineer known for years with his integrity
4) Ahmad is pushing Mohammad seriously to give the details of the bids and threaten to end their friendship
5) Ahmad offered to share some of the profit with Mohammad if his brother won the tender

Discussion

Muhammad now is in a difficult situation where he has to decide what to do. He could be in the safe side and take an ethical decision sacrificing his ten tears friendship with Ahmed. Or he could take an unethical decision so save that friendship and to profit from the wining contractor. For this we will discuss some different scenarios Mohammad could take and which rule is violated in each.

A) First Scenario

In the first scenario Mohammad could just simply leak the details to Ahmad to save their friendship and also to get the promised profit if Ahmad's brother won the tender. Although this could be an easy decision to take but however, the consequences for this decision are more harmful. This scenario includes a conflict of interest as rule four (4.7) states, Mohammad seeks to get a profit by helping one contractor instead of aiming to choose the best bid for the good of the company. Also Leaking the bids details considered a violation of rule four (4.2) as Ahmad requested the bids details which is considered confidential information and disclosing such information without an approval is considered a violation. Another violation is clearly illustrated by the profit received in case Ahmad's brother won the

tender, this is a clear violation of the rule four (4.8). Although Mohammad could save his friendship with Ahmad and get some profit but the consequences of violating the previous rules are unneglectable.

B) Second Scenario

Mohammad could be afraid of leaking such confidential information, so he decides to create a position in the team to include Ahmad in the responsible team, and then Ahmad will get the details himself as he as now a member of the team and leak the bids details to his brother, so both could be happy as Mohammad saved their friendship, and Ahmad helped his brother to win the tender. However, included Ahmad in the team for that purpose is considered a violation of rule four (4.3) as Ahmad was include not for his good performance but for another purpose, while there could another engineer who deserves this position more than Ahamad. Also, this behavior violates rule three (3.5) as Mohammad participated to cover up the leaking action done by Ahmad.

C) Third Scenario

In the third scenario, Mohammad could just refuse to disclose such information but, to satisfy Ahmad's need he will try affect his team judgment by underrating other bids and recommend the offer coming from Ahmad's brother. As these judgment and discussions Mohamad uses to convince his team members are not scientific and based on personal interests. Then this is a clear violation of rule five (5.1) as the decision making was based on satisfying Ahmad's need to make his brother bid the one accepted by the company instead of selecting the best bid based on the engineering fundamentals.

D) Fourth Scenario

One Scenario happens if Mohammad immediately refused Ahmad offer, and reported that to the responsible department so they can take any required actions to save the future of the company. Although this decision may lead to ending a friendship that lasted for more than ten years, but it is an ethical decision and the most recommended action As there is a commitment to the code of ethics, and to our Islamic learnings. On the other hand, Mohammad and Ahmad relation as friends could be affected as Ahmad threaten. But however, this could not be as harmful as Mohammad losing his integrity and ethics in order to satisfy Ahmad needs in each time.

Ethical Discussion

As we have seen, the fourth scenario could be the best scenario to have as Mohammad will not make any unethical decision that could harm him or anyone else. However, in many cases it could be difficult to choose from the different possible actions. As in this case, the friendship was a ten years old friendship which could be difficult to sacrifice, but if we considered the other options, their consequences are more harmful than ignoring Ahmad needs and reporting it to the responsible department. But however, if Mohammad chose an unethical behavior just to save their friendship, then in addition to the ethical violation, he saved himself from having a poisonous friendship.

Conclusion

In this report, we have discussed a study case where an engineer has to make a decision, the different decision the engineer takes have different consequences some could be more ethical than other, and some may harm the engineer career and the society, and we consider them as unethical decisions. We also discussed the possible scenarios for the case study, and considered the best available decision where no ethical violation occurred.

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EE-499

Name: Sulaiman Abbas
College ID: 1845862
Team#:3
Member#:2

Ethical Case Study

Saudi Council of Engineers (SCE) [1]

General rules:

Rule One: Every engineer should build her/his professional reputation based on efficiency and proficiency of her/his services, and away from unfair competition with others.

Rule Two: Every engineer should seek to develop her/his personal abilities and efficiency, and should also provide professional development opportunities for engineers and technicians working under his supervision.

Rule Three: Every engineer should be committed to promoting the fundamental values and principles of the ethics of the engineering profession and should plant them within society. Regarding her/his conduct, every engineer should be in ways that support and enhance the prestige and dignity of the profession and the secretariat of the locally and globally.

Rule Four: Regarding professional issues, every engineer shall act as a careful agent to the employer, and shall avoid any conflict of interests.

Rule Five: When submitting her/his ideas, views and decisions, every engineer should be keen to be objective and honest and confined to her/his field of expertise and professional experience.

Rule Six: When providing professional services, every engineer seeks to apply the highest standards of safety and environmental protection in order to achieve the public interest of individuals and society.

Case: Reassignment to another location (adapted from NSPE Case No. 16-9) [2]

Mohammed works for Engineering Solutions, an engineering firm owned by Ali. Engineering Solutions does business in several cities but is headquartered in Riyadh. Engineering Solutions has a policy to not terminate an employee unless they provide the employee with at least 90 days of written notice of termination. Due to short-hand issues confronting Engineering Solutions, Ali decides to reassign some of its employees, including Mohammed, to Jeddah away from Engineering Solutions headquarters in Riyadh where Mohammed has been working. As a result, Mohammed will need to relocate with his family. Engineering Solutions advises reassigned employees that they have one week to decide and their failure to accept reassignment would constitute their resignation of their position with Engineering Solutions. Mohammed is unable to relocate due to family issues and claims that, as a practical matter, Ali's decision to unilaterally reassign Mohammed to another location constitutes a violation of Engineering Solutions' written notice policy of providing at least 90 days of "written notice of termination," and therefore is unethical.

Discussion

The case at hand showcases a situation where two engineers and a company are faced with an issue of re-location. The company has its policy about re-location in which it must notify an engineer within 90 days. Furthermore, the company gave Mohammed an ultimatum of moving within a week or getting fired/resigned.

Scenario 1: Mohammed accepts to re-locate within 1 week of receiving the ultimatum, he and his family have to move to Jeddah. With this option Ali violates **Rule two** of the SCE Ethics code.

Scenario 2: Mohammed does not respond to the ultimatum and gets fired from Engineering Solutions. With this he violates **Rule three** of the SCE Ethics code.

Scenario 3: Mohammed accepts the re-location ultimatum and relocates with his family to Jeddah. In parallel, Ali reimburses Mohammed with a raise to his paycheck.

Scenario 4: Engineering solutions, owned by Ali, sticks to their policy and allows the engineers to reply within 90 days and manages the short-hand issues with temporary solutions.

In my opinion, the situation is tricky. Both parties need each other and a solution must be found. To determine, Scenario 1 is unethical in the sense that Ali is not being professional with those working under his supervision. Scenario 2 is really bad; Mohammed is not behaving with the principles of engineers and should not happen. Scenario 3 is some-what acceptable but Mohammed's family would suffer by moving to a new city. Finally, I believe **Scenario 4** is the best outcome, it shows that the company sticks to its policy and would not harm its engineers. Furthermore, since the issue is not financial but short-handed, the company can manage until their engineers make a choice.

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Report 3 - Ethical Case Study

-Fall 2021-

Course: EE499

Students: Wael Aldhaheri – 1846978

Supervised by: Dr. Mohammed Bilal

1 Introduction

Engineers face situations they must choose between right and wrong. But sometimes it's not very clear-cut and it's hard to discern between the choices. There are three main things that affect the decisions of engineers: Morals, Ethics, Law. Morals are usually internal, and they differ from a person to another. Ethics and laws usually come from the external world. Laws are set by governments and ethics are usually set by professional societies of each profession. In this report the focus will be mainly on ethics.

2 Saudi Code of Ethics

According to the **Saudi code of ethics** an engineer shall follow these six general laws:
Rule One: "Every engineer should build her/his professional reputation based on efficiency and proficiency of her/his services, and away from unfair competition with others."
Rule Two: "Every engineer should seek to develop her/his personal abilities and efficiency and should also provide professional development opportunities for engineers and technicians working under his supervision."
Rule Three: "Every engineer should be committed to promoting the fundamental values and principles of the ethics of the engineering profession and should plant them within society. Regarding her/his conduct, every engineer should be s in ways that support and enhance the prestige and dignity of the profession and the secretariat of the locally and globally."
Rule Four: "Regarding professional issues, every engineer shall act as a careful agent to the employer and shall avoid any conflict of interests."
Rule Five: "When submitting her/his ideas, views and decisions, every engineer should be keen to be objective and honest and confined to her/his field of expertise and professional experience."
Rule Six: "When providing professional services, every engineer seeks to apply the highest standards of safety and environmental protection in order to achieve the public interest of individuals and society."[26]

3 Case Study

1. Engineering Dilemma

Fahad is a clinical engineer working in a hospital in Saudi Arabia. The hospital has a rule that if anybody makes a mistake or even almost made a mistake, they should report it themselves and they would be treated more leniently. The hospital also has a system that automatically uploads ECG recordings to the hospital information system allowing the doctors to view them easily. A doctor requested from the nurse to take an ECG recording for one of the patients **Saeed**. After a few hours Saeed passed away due to a heart disease that would have been treatable if caught early but the doctor never received the ECG recording. At first, the administration thought that the nurse didn't take an ECG recording and she was at fault. However, **Fahad** investigated the ECG device and found out that the CMOS battery has failed, and the date and time reset causing the ECG recording to appear in the system as something that was recorded years prior.

2. Case Analysis

In this case **Fahad** needs to decide, whether to report the device problem and prevent that mistake from happening again or to stay silent and the nurse might be wrongfully punished. People lives are at stake and **Fahad** needs to choose the ethical decision. These are the possible scenarios:

1. Fahad does nothing: Fahad could stay silent and not report the problem with the CMOS battery. Which would endanger lives because that failure could happen again, and another person might be harmed because of the same mistake. In addition to that the nurse might be wrongfully punished. This decision would be unethical and Fahad wouldn't be acting in compliance with **Rule Six:** "When providing professional services, every engineer seeks to apply the highest standards of safety and environmental protection in order to achieve the public interest of individuals and society."[1]

2. Fahad fixes the device but doesn't report: Fahad could also fix the ECG device but doesn't report the problem to the administration. This would be a band aid solution that only temporarily solve the problem but doesn't resolve the underlying issue that the CMOS batteries need to be replaced periodically. Although this is marginally better than the first scenario this still violates **Rule Six**

3. Fahad fixes the device and reports the problem: This would be the best solution; Fahad fixes the device and also reports the problem to administration so that they can come up with a preventive plan to stop this from happening again.

4 Final Ethical Discussion

Based on the rules of the Saudi code of ethics, **scenario 3** would be the best one. Because Fahad would be helping in achieving what is best for the patients and their safety.

5 References

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APPENDIX B: IMPACTS OF ENGINEERING SOLUTIONS

Sports Article: Physics in Football [1]:

All objects adhere to gravity, the ball behaves in many ways during a match in a way that abides to the physical laws of our world. The ball has a trajectory and movement which is dependent on many variables; It can rotate on itself depending on the air above/under it and on the kinetic energy transferred by the players' leg. Furthermore, footballers are able to shoot a ball in a parabolic curve. This is achieved using the magnus effect. By kicking the ball off-center and rotating in horizontally a ball can be shot in a way that is hard for a goalkeeper to react to. In a penalty, considering the three factors; strength, precision, placing the ball and keeping it off the turf a shot can be about 90km/h which when aimed at a corner as said before, is impossible for a goalkeeper to react to.

A header can reach speeds up to 30km/h which is nothing exceptional compared to a footer which can reach up to 130km/h. A very impressive number. A very forgotten topic is the duration of impact, which ranges from 14-30 milliseconds. To explain, this means that the ball can exert forces up to 30 times the gravitational force on the players' head. Furthermore, on speed, a player named Kylian Mbappe is known for his speed, he can reach a speed of 36km/h while controlling the ball by applying the right amount of force.

What changed in my mind in this article is the speeds that the ball can reach. I had the notion that the ball is moving fast but not at these speeds! It is very interesting that players can shoot a ball at 130km/h.

Another aspect is the magnus effect. I had no idea that the players were using physics to perfect certain shots to boost their chances of scoring a goal. Many techniques are based on scientific fact and it is very impressive.

The information provided in this article has refreshed my memory on physics. Furthermore, sports has always been integrated into society and thus, the improvement of sports will require better electrical equipment to showcase the events, better lights for the stadium and efficient medical solutions that all require electrical engineers to participate in.

Environmental Article: How to Solve the Climate Change Problem [2]:

To summarize the article, the ongoing climate change crisis is expanding and not backing down. In the USA, it is expected that the CO2 emissions from all sources will remain constant within the next 30 years. To explain, this means that the USA is not reducing its CO2 output and many other countries are following suit. Furthermore, the idea that adding wind/solar will fix the issue is completely wrong. This is due to the fact the carbon-based systems are already in place and paid for while we add green choices on top will not fix the issue and cause economic collapse.

The article moves on to give a solution, Decarbonization. This happens when you build solar and wind farms. Achieving a zero-carbon footprint would require a nation to implement a decarbonization law that mandates the amount of decarbonization that occurs each year. Decarbonizing power is easy, it would cost the USA an increase of $0.002/kWh while decarbonizing 85% of electricity. If the green solutions are easier to use and readily available,

many consumers would use them. However, decarbonizing most of our electricity is easy, moving to higher percentages is the real challenge.

I had the idea that adding wind and solar energy solutions on top of our current ecosystem is the solution, the article changed my mind about this since it gave a different angle to look at. Having oil in the first place is the issue and just adding a few solar panels will not change the final outcome.

Decarbonization laws are a new concept to me, I had the notion that countries already implemented these laws rather than ignoring climate change. Many countries such as China or the USA should implement them as quickly as possible.

Climate change affects everyone, as an electrical engineer, not having electricity will remove me from society if we do not act fast. On the other hand, it could open for more jobs for electrical engineers to work on solar panels or wind turbines. Many Power Engineering related jobs can be created from the climate change solutions. It could also open up a new field of electrical engineering.

Social Article: We've Entered a New Era of Streaming Health Care. Now What?[3]

In this article, the author talks about how very few people really enjoy going to the doctor. Often, people are afraid of getting bad news from visiting the doctor or convince themselves that they don't need to go to the doctor. However, the pandemic has forced a transition to virtual health care delivery (telemedicine). The author also thinks that the traditional health care model is really more of a "sick care" than health care. Because the current system waits for a patient to get sick before it intervenes. And the author suggests that streaming health care can make health care more proactive and helpful in preventing illnesses and not just treating them. Which can be done by using at-home devices and virtual visits that bring about a steady flow of information between the patients and the doctors.

This new system of health care paves the way for earlier health interventions which is beneficial in preventing the progression of diseases. And consequently, avoids the costs of late-stage treatment. The author suggests that self-tracking devices can provide important data for health care providers. In addition to the use of these digital devices in diagnostics, there are also digital therapeutics. One of which is called Nightware. Which is a system that helps people with PTSD-associated nightmares get better sleep by delivering a vibration stimulus if it detects that the user is having a nightmare, which ends the nightmare without waking the user.

After reading this article, I started to believe that telemedicine is a very important part of health care. And it should be utilized more, especially for when people are suspecting that they might be ill. Currently, people just google their symptoms and "diagnose" themselves which usually does more harm than good. But with telemedicine, doctors would be more accessible, allowing people to ask doctors questions without needing to leave the house.

This article inspires us to always strive for more and to not just settle for old solutions. Although the traditional health care system was "working", telemedicine is a great addition to it. It also encourages biomedical engineers specially to work on introducing and improving this field in Saudi Arabia.

[Business Article]: Automated video editors will intelligently merge simultaneous streams of events[4]

In this article, the writer discussed the potential future impact of the artificial intelligence on wedding video graphing. The writer believes that the next revolution in the wedding video graphing industry will be led by AI. The AI system will autonomously combine the videos from its multiple distributed video devices, including smartphones, drones and even action cameras to automatically produce a high quality multicam video production. The writer expects this to happen within the upcoming few years. As there are already AI systems with great powers in object recognition and video processing our smartphones. The basis of the systems includes joining multiple cameras and a AI cloud-based system. Each camera streams to the cloud and the system will sync the all the coming scenes. Then, it will determine the distance of the objects in each video source and adjust the camera directions. The implemented algorithms, includes the facial and speech recognition to sync the video and audio contents.

Economically, this AI system can just take the wedding videographers out of business or at least tighten the business opportunities in front of them. In the coming future, it is also expected to reduce the human hands even in the tasks that require the videographer to react when no close-up shot of a family member in the wedding, as the high-speed connection of the system and the real-time multicamera production enables the system to include a feedback loop to trigger the specific camera to take a closer shot and respond faster to the case. This will further reduce the need of an extra supervisory human hands in this business.

After reading this article, I realized how much AI system could impact the business opportunities. Although it could be a great opportunity for some people in the tech field. But on the other hand, it could be the end of some businesses. AI systems in general could play a role in reshaping our future economic system, through opening new opportunities and close others.

As an electrical engineer, this article motivates to join AI field to provide a touch in reshaping the future business opportunities that could be totally different from the ones we see now. On the other hand, it pushes the world toward realizing the need of having an organization to regulate the growth of the AI field in manner to reduce its sides effects on some business.

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