`Achievement Standard 91050

Demonstrate understanding of the role of subsystems in technological systems

1. **Identify the subsystems in your autonomous robot.**

- Power Source (Battery)
- H-Bridge (Motor Control)
- Picaxe 14m2 (Microcontroller Chip)
- LCD
- Sensor (Bumper Wire Switch- Brass Plates)

2. **Describe the role of the subsystems in your autonomous robot.**

- The Power Source (battery) is the electricity applied to power/function my robot. For my robot, i have applied 2 separate power sources, a 6V lithium ion battery to produce a much more powerful (faster spin) performance from the wheels (H-Bridge Motor control), and a 4.5V source (3X1.5V AA cells) to power the picaxe which requires 5V or less to function. These power sources are separated from each other, meaning that my robot has 2 circuits that run on different amount of power. This is to ensure that neither circuits are sharing a limited amount of electricity, thus may result in either a lack of power for the H-bridge (motor control) and a over power on the picaxe.
- H-bridge Motor control is to allow my robot to move forward and reverse autonomously. This motor control relies on the shifting direction of current when a sensor picks up signals to trigger an autonomous reaction. The H-Bridge consists of NPN and PNP transistors transitioning power to rotate the motor. If the motors are spinning in one direction and the sensor indicates a command to spin the other way, current flows opposite from its prior direction, thus resulting in reversing the wheels.
- The picaxe is the mind of the robot, it holds the commands of all its processing and sends electrical currents to function the robot's components. My picaxe 14M2 has 14 pins, each having hooked up with a exterior component (resistors, LED's, LCD, and transistors). To give out current from the picaxe, the microcontroller requires programme commands specific to the components connected to the pins. This could simply be turn on or off commands, later to complex commands such as LCD or sound programming (Piezo).
- LCD (Liquid Crystal Display) is a screen that displays digital text. It receives data (text) from the picaxe connected, and the data is displayed on its screen in

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moderated speed. It consists of a small pixel screen and a independent PCB, which is used to process current (data) received from the microcontroller, picaxe 14m2.

- Sensor (Bumper Wire with Brass plates) is put in front of the robot to detect physical contact with touching obstacles. Once an activatable amount of force (contact) is pushing the wire back, the sensor sends current to the picaxe indicating a reaction must be made to fix the problem (The reaction may be to reverse the wheels so the robot moves away from barricading obstacles; for example chairs/walls). it consists of metal spring wire and brass/copper plates, both conductors of electricity.

3. **<u>Describe how subsystems work together to allow the robot to function.</u>**

- The Power Source contains energy that power the components installed on the robot. On my robot, there are 2 power sources used for 2 separate subsystems, the H-bridge and the Picaxe 14m2. The Picaxe microchip relies on the 4.5V (3x AA Batteries) for a safer and weaker source of power (Picaxe can handle 5V max.) , as for the H-bridge i have connected a 6V lithium battery for a much more powerful source of energy in order to move the wheels faster.
- For my H-bridge to control my DC motors, it is connected to the picaxe to receive currents through its input/output pins, therefore is able to follow commands programmed in the Picaxe chip indicated through the bumper sensor to trigger an autonomous reaction to solve the problem (In this case, the H-Bridge would follow the commands from the picaxe to reverse/turn away from the obstacle). The transistor H-Bridge consists of NPN and PNP transistor switches, each individually saturates from positive and negative charge. PNP transistors stands for positive, negative, positive, this meaning that the 3pins of the transistor are connected to positive or negative charge (middle pin goes to picaxe (+), other to positive charge and negative charge). This also applies to NPN transistors which is more leaned towards the negative side of the circuit. These transistors stand for each base of current that runs in the circuit, meaning that PNP transistors are components that control the current going through the motor to spin in a particular direction, as when the NPN transistors are triggered, the flow of charge changes direction directing the motor to spin the other way. This is called sinking and sourcing, the process of taking and giving positive charge in the H-Bridge.
- The picaxe chip can function only by the application of the 4.5V source of power (AA batteries). This subsystem sends out current from the battery to power connected components (H-bridge's transistors, sensors etc.).
- The LCD is an additional subsystem installed onto the robot for a visual display of text. The text seen on the screen is controlled by the signals the picaxe is sending to the LCD, thus requires the programming on the picaxe to match the specific programme of the LCD.
- The sensor is a bumper wire attached onto the brass plates (conductor), which is able to send current to the picaxe when the switch is closed to

indicate specific actions to be made. When the picaxe receives signals to take command, the picaxe sends out current to the H-bridge which triggers it's purpose, thus reversing the wheels and move away from obstacles.

4. Explain how control and feedback allow subsystems to function in your robot

- My P9000 motors are connected to the Picaxe through a transistor switch and a current limiting 330R resistor, which is hooked up to one of the output pins of the selected picaxe – (C.0, B.5-14M2). The circuit's power source is from the voltage of a 6V lithium battery, reduced down to 5V using diodes, therefore it would not harm the picaxe which requires very little voltage to power (5V). Current travels into the picaxe, and the output pin that is connected to the components (resistors-transistors) receive current flowing through and out into the base pin of the NPN or PNP transistor, opening the switch to allow current to travel to the emitter to power the motors. These NPN or PNP transistors require 0.6-0.8V, but recommended 0.7V for best result, not too weak, not too strong. The P-9000 motors have a capacitor that absorbs in electronic noise which interrupts the signal between the motors and the picaxe, therefore sometimes the motors would not function properly due to the disturbing noise. To reduce back-EMF, diodes are connected to the motor to reduce the voltage that travels back against the flowing current going through which may fix specific issues regarding the speed of the motors and its overall function to spin in one direction. (Before H-Bridge).
- The way my robotic vacuum robot can travel in both directions (up & down) is by applying a sensor such as a bumper wire in front of my robot to sense contact with objects and connecting it with the simple transistor H-Bridge. The contact with the bumper wire pushes the metal wire against two brass plates, which are both hooked up to the positive rail connected to the picaxe, thus triggers the chip to allow current to travel to the transistors switches that turns on the motors. Each H-Bridge switches on 1 motor (therefore I have 2), controlling its direction from spinning forward, stop, and go backwards when in contact of incoming obstacles. The sides of the H-bridge are switched on and off by programming HIGH and LOW pins that the picaxe and transistors (PNP & NPN) are connected. Example, when 1 pin of the picaxe is HIGH, the other pin should be LOW so that the motors are spinning in one direction. The current going through that HIGH pin travels to either your NPN (Negative) or PNP (positive) transistors and the current should find the easiest way to connect positive charge and negative charge together in the circuit. The transistor does not connect vertically to the transistor above or below it because and L.E.D which has a – and + pin prevents the wrong type of charge from traveling into the component through the wrong way, therefore the current goes diagonally to where the + pin of an L.E.D is connected to an transistor (NPN or PNP) and turns on the motor in one direction. To spin the motors backwards, simply swap the HIGH pin to LOW and the LOW pin to HIGH to change the direction of the flowing current. The process of giving positive charge (HIGH) is called "sourcing", and the process of taking positive (LOW) is called "sinking".
- Serial communication – This is when the picaxe sends data in small amounts at a time to an component. This is fast and convenient compared to parallel communication where it sends several/all data at once. There is serial communication in my picaxe to my LCD, therefore each letter appears faster on my LCD because the data being sent are at a much faster speed because it is small. Serial communication works best for my robot because it only requires 1 pin on my picaxe to send data, rather than the parallel communication where it will take up a lot more pins on the picaxe which could be more useful to use on other techniques such as the H-Bridge.
- Feedback within electrical components are the bits and bytes that transfer through the components, signaling whether or not its function is still required after a trigger. The bits are mini storages containing just a 0 and 1 (0 meaning off and 1 meaning on). a byte are 8 groups of bits; eg. 0101100, and also stores a particular letter like "X", "Y", or "Z". Feedback is the signal that loops from the output back into the input to tell it what to do. For example, When the sensor is triggered and the picaxe is told what to do, this means the motors will spin in the

other direction due to the programme in the picaxe to do so (H-Bridge). But the motors don't reverse forever, therefore feedback is given from the motors (H-Bridge) to the picaxe to say that reverse is no longer required and can return to normal function. this is the process of 0101011, where it sends current and stops current from powering the system. There are positive and negative feedback, positive feedback being a loop gain in the circuit meaning more current from the input is needed into the output. This feedback can sometimes be too much (Oftenly more than 1 (into decimaled units) and destroy the circuit), therefore negative feedback is sent from the output to close or to reduce the input distributed from the picaxe.

5. **Explain the advantages and disadvantages of subsystems in your robot. (Explained in Question 6.)**

6. **Discuss the advantages and/or disadvantages of subsystems used in particular technological systems**

- Subsystems are an advantage for my robot in general because each system can be built in step by step, therefore each subsystem installed towards constructing this robot can be built following specific instructions and are less time restricting (Decide which one is easier to install). They are all connected separately from each other, therefore if one was to not work/function properly, the problem within specific components would not disrupt the process of other systems (e.g H-Bridge would not affect the system of the LCD, or drain the power of other sources). But because the picaxe14m2 is the main source of control and function of the robot, if the picaxe is unable to process information to distribute current to other connected components, then subsystems like the H-Bridge, Bumper sensor, and the LCD would be meaningless to install as it requires a programmed microcontroller chip to activate it's commands.
- The H-bridge is disadvantage towards my robot as it does not clearly indicate specific errors in the formation of the circuit (wrong direction of installing components) and other components used to operate the motor control. if we have a clear indication of components placed incorrectly (e.g light sensors or sound), then it may not be a disadvantage for newbies like me who cannot clearly indicate an error in the circuit (LEDs show whether or not there is current travelling in the H-bridge but it requires everything installed so that both wheels are moving). The H-bridge also hoggs a lot of space (pins) of the picaxe, thus requiring 4pins of an 14M2 picaxe. It's advantage because it seems basic for a small project of controlling a mini robot, thus saves time and money spent on transistors and resistors to construct the H-Bridge.
- The advantage of using AA batteries for the picaxe is that they are easily replaceable and cheap to do so. They provide the recommended amount of electricity to power the picaxe (1.5x3=4.5) and are reliable in terms of draining small, considerate amounts of power from the source. They are small and fit well onto my small robot, an advantage of leaving space on the robot for other components. It's disadvantage lies on it's temporary reliability, meaning it does need to be replaced frequently if in use for a long time, but its cheap cost and easy accessibility (Supermarkets and dairies) makes up for it's temporary and small production of electricity.

- The picaxe is advantage for my robot as it consists the right amount of input/output (8) pins needed for all my components (LCD, H-Bridge, Piezo, Sensor). It would be disadvantage if we were to decide to install more components connected to the picaxe as we will run out of pins, thus maybe a larger picaxe may be more preferable to apply when needing more pins to receive current from. But because my robot is a small project, only a minimum of components can be installed, therefore the Picaxe14M2 works great and issueless on my robotic vacuum cleaner.
- The LCD (Liquid Crystal Display) has an advantage on my robot as it uses serial communication to transcend data from the picaxe. This results in a maximum of 1 pin on the picaxe to ascend data to the LCD, thus saving a lot of space on the circuit. But serial communication is slow compared to parallel, as it only sends a single unit of data per transition, as parallel can send multiple data at once to the LCD. But parallel requires a lot of pins on the picaxe, thus preferring serial communication as it presently works fine and smoothly, and saves a lot of space. In terms of physical features, it fits the properties of an robotic vacuum cleaner, but for a modern and more advanced impression of robotic technology, OLED screens with AMOLED displays (Smartphone technology) will be much more pleasing but more complex to programme.
- The Bumper wire is a great sensor that picks up contact from obstacles ahead of the robot, with a small sector range appropriate for surface navigation. I've found that the sensitivity of the wire is good but not great, sometimes missing the contact from an angle of direction. But with its sensitivity on close range, a sector of space under the wire is untouched by the robot, thus effecting the results/expectation of being able to cover an entire surface area of the floor (This may be the corners or the benches (perimeter) of the walls that may contact the wire).

7. **<u>Discuss the implications of subsystems on the design, development and maintenance of technological systems.</u>**

•.1 Implications on design

With the design of my circuit, i had not calculated accurately the size of my PCB and how well it fits onto my plastic cassette. my PCB is 100cm2, almost the same area as the the body circumference of the cassette, this resulting in alternate locations to place my PCB on the robot. My circuit had a lot of unused space which could have been removed during digital manufacture to reduce the overall size of the PCB, but because i haven't, it resulted in a messy prototype with wires touching and the components compressed to close together. It would have been easier to have thought about drilling bigger holes on the PCB to install with pillars on top of my robot cover, but the space the H-Bridge has occupied on the PCB was far too great to leave space for alternative drilling. The LCD was also occupying space on top, meaning a 100cm2 square PCB would need to overlap the borders of the robot but couldn't do so due to lack of space on PCB for drilling. The design of the subsystems were tidy and organised in terms of layout and spacing, but the problem lies on the proportion of the robot being a lot smaller than the average "robotic vacuum cleaner", this resulting in everything needed to be design a lot more smaller to fit on the robot itself. To improve the design, i would have prefered more advanced electrical components installed onto the robot to have a more preferable design for robotic technology, e.g Infrared sensors over bumper sensor in terms of quietness and smoothness of reaction, a HD monitor instead of a digit LCD that displays text only and not images, and maybe a speaker or voice audio to have sound productions or voice recognitions to make the project seem more developed.

•.2 Implications of development

In the development of the robotic vacuum cleaner, i struggled learning the design of the H-bridge motor control resulting in long term stages into installing the H-bridge. This is due to lack of knowledge with electrical theories and experience building an electrical robot. It was not difficult to solder on components onto the PCB and constructing the cassette, but it ended up taking a long time due to the replacement of the break-board and specific components needing to be replaced or fixed to adapt to the size and layout of the PCB. The construction/development of the robotic vacuum cleaner had clear instructions in terms of the physical build of the project, but was lost in the function of the robot (Programme of the Picaxe). The development took a long time and was not as smooth as expected, thus needing every subsystem (power source, picaxe, H-bridge, sensors) to fit together and work coordingly to display its maximum performance, requiring care and knowledge of how the subsystems function.

•.3 Implications on maintenance

The maintenance of the robot is well preserved, replacing a temporary break board with a permanent PCB circuit board to ensure that voltage (current) is still flowing around the circuit. The soldering of the components is a permanent process connecting the whole circuit together, meaning that wires aren't that easily to be loosen by twitches or major contact and smaller components like resistors and transistors don't fall out. As for the subsystems, everything should work smoothly until the power source is reduced or the programme is changed or incorrect. Everything should have a permanent function until potential short circuit or water interaction to destroy the circuit as a whole. But with per subsystem laid out separately, it implies that individual replacement is possible and not to complex to do so.

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