Week-5

What we have done:

- Motors are tested (stepper motor (Mini stepper motor - 28 BYJ 48), mini DC motor)
- Designed PID controller for dc motor.
- Brainstorming and researching about battery and charger.
- Started to develop 3D Models and CAD drawings
- Set up Ubuntu and ROS to the Raspberry Pi.

Participants:

- All members of the group participate in meeting.

1 Battery Selection

Battery Type	Pros	Cons
Lithium-Ion (Li-ion)	- High energy density for longer usage. - Low self-discharge rate. - Good power density for high-power applications.	- Relatively expensive. - Requires protection circuit. - Aging effect.
Lithium-Polymer (Li-Po)	- Higher energy density than Li-ion. - Lightweight and flexible form factor. - Lower risk of leakage.	- More expensive than Li-ion. - Sensitive to overcharging and conditions leading to swelling. - Requires protection circuit.
Nickel-Metal Hydride (NiMH)	- Higher capacity than NiCd. - Less prone to memory effect than NiCd. - Environmentally friendlier than NiCd.	- Lower energy density than Li-ion. - Higher self-discharge rate. - Temperature sensitive.
Nickel-Cadmium (NiCd)	- Good performance in low temperatures. - Durable with high discharge rates. - Cheaper than other types.	- Lower energy density.
Lead-Acid	- Economical for larger power applications. - Mature, reliable technology.	- Heavy and bulky, unsuitable for portability. - Lower energy density. - Requires maintenance.

Table 1: Comparison of Different Battery Types

1.1 Battery Selection Criterion

Energy Needs, Size and Weight Constraints, Lifecycle and Reliability ,both initial and long-term costs.

1.2 Recommendation for Desk Robot

The primary choice for a desk robot would be **Lithium-Ion** batteries due to their high energy density, efficiency, and power density.

2 Li-ion Battery Configuration

The decision between using a single cell (1S) or two cells in series (2S) configuration for powering the robot.

2.1 One Cell (1S) Configuration

Voltage Range: Typically 3.7V (nominal) to 4.2V (fully charged) for a Li-ion or Li-Po cell.

Pros:

- Simpler charging and circuit design.
- Lighter and possibly more compact.

Cons:

- Requires a boost converter to achieve 6V for actuators.
- Added complexity and potential decrease in energy efficiency due to the boost converter.

2.2 Two Cells in Series (2S) Configuration

Voltage Range: In series, two cells have a range from about 7.4V (nominal) to 8.4V (fully charged).

Pros:

- Easily provides the required 6V for actuators without a boost converter.
- Potential for better actuator performance due to higher voltage availability.

Cons:

- More complex charging circuit needed for cell balancing.
- Heavier and requires more space.
- Necessitates a step-down converter to provide 5V and 3.3V, adding complexity.

2.3 Recommendation

Considering the requirements, a **two-cell in series (2S) configuration** is recommended. This setup naturally provides the necessary voltage for the 6V actuators and requires a step-down converter to supply 5V and 3.3V for other components. Despite its added complexity, this configuration is likely to offer a more stable and efficient power solution for both the robot's 5V and 6V requirements.

3 Charger Module Selection for 2S Li-ion Configuration

3.1 Key Considerations

- **Charging Protocol:** CC/CV method suitable for Li-ion batteries.
- **Balancing Feature:** Essential for even and safe charging of both cells.
- **Safety Features:** Including overcharge, overcurrent, and thermal protection.
- **Size and Integration:** Compact module for seamless integration.
- **Input Voltage Range:** Compatibility with the robot's power source.
- **Output Specifications:** Suitable for 2S configuration (around 8.4V at full charge).
- **Indicator Lights:** For charging status.
- **Connectivity Options:** Such as micro-USB or USB-C for ease of charging.

3.2 Recommended Charger Modules

1. **TP4056 with Dual Cell Configuration:**
   - Suitable for 2S setup with additional balancing.
   - Features overcharge, over-discharge, and short-circuit protection.
   - Compact and cost-effective.
2. **BQ24259 by Texas Instruments:**
   - Integrated solution for 1S or 2S Li-ion batteries.
   - Dynamic power path management and safety features.
   - Supports USB input, higher efficiency.
3. **MCP73831/2 from Microchip:**
   - Adaptable for 2S with additional circuitry.
   - Offers thermal regulation and safety features.
   - Different current rating options, compact design.
4. **LT3652 by Linear Technology:**
   - Designed for multi-cell configurations.
   - Integrated cell balancing, wide input range, and safety protections.
   - Robust performance, suitable for critical applications.

3.3 Conclusion

Selecting a charger module for a 2S Li-ion battery in a robot involves balancing the need for appropriate charging protocol, safety features, and integration constraints. The TP4056, BQ24259, MCP73831/2, and LT3652 are exemplary models, each offering unique benefits suitable for different applications. The choice should align with the robot's specific power management requirements and design considerations.

4 Innovative Charging Methods for Desk Robots

To make our robot as flexible as possible

4.1 Charging via Smartphone Inductive Coupling

Leverage the inductive coupling technology present in modern smartphones, capable of wireless charging. By equipping the desk robot with a receiver coil and placing it near the smartphone's transmitter coil, energy can be wirelessly transferred from the smartphone's battery to the robot. This method utilizes electromagnetic fields for the transfer of energy, offering a convenient and portable charging solution for the desk robot. It harnesses existing technology in a novel application, providing an efficient use of the ubiquitous presence of smartphones in the modern environment.

4.2 Integrated Power Bank System

Implement an integrated power bank system within the robot's design. This system involves embedding a high-capacity rechargeable battery within the robot, which can be charged externally via standard power sources. When the robot's primary power depletes, it automatically switches to the power bank, ensuring uninterrupted operation. This design not only enhances the robot's autonomy but also allows for greater mobility and functionality in environments where direct power sources are scarce or unavailable. The integration of this system calls for sophisticated energy management strategies within the robot's circuitry to efficiently balance charging cycles and power usage.

4.3 Electromagnetic Induction from Lightning Simulators

Using a scaled-down Tesla coil to create mini lightning, the resultant electromagnetic fields induce currents in the robot's receiving coil, thereby charging it.

4.4 Biomechanical Energy Harnessing

Utilize a miniaturized biomechanical system, akin to a hamster wheel, but powered by insects such as crickets. These insects generate mechanical energy when striving to reach a stimulus, which is converted into electrical power for charging the robot.

4.5 Piezoelectric Dance Mat

Employ a small dance mat made of piezoelectric materials, which generate electricity under mechanical stress. The robot's pre-programmed dances on this mat produce energy to recharge its batteries.

4.6 Thermoelectric Charging Plate

Exploit the Seebeck effect in thermoelectrics to create a charging plate with a temperature gradient. Utilizing waste heat sources like a hot coffee cup or ice pack on one side of the plate, generates electricity for charging.

4.7 Wireless Charging from Acoustic Energy

Convert ambient sound, such as music or office noise, into electrical energy using piezoelectric or electrostatic transducers. This acoustic energy is wirelessly transmitted to charge the robot.

4.8 Photosynthetic Charging Panel

Integrate bio-hybrid solar panels that utilize living algae performing photosynthesis. These panels convert solar energy into electrical energy, providing an eco-friendly charging method.

4.9 Kinetic Energy from Office Activities

Harness kinetic energy from office activities like door closing, typing, or walking, using kinetic energy harvesters. This energy is generated and stored for robot charging.

5 3D Models and CAD drawings