Document (Technical Details for Proposed Robot)

1. Type of Robot.: Application-based (Military) Robot

2. Robot Assembly Design (Proposed Diagram):

Fig. Proposed design of Dharma

3. Components to be used: Enlist all the components with their make/company in four groups as enlisted in the following

I. List of Structure components: beams, brushes, shafts, belts, plates, pins, pullies, wheels, connectors, batteries, motors etc.

	Structure Components	MAKE
1	Belts(HTD 5M pitch 630mm length)	Bolton Engineering Products
2	Carbon Fiber tube	ThinkRobotics
3	Drive bearings	IndianLocalShop
4	Bearings	Amazon
5	steel bar	IndianLocalShop
6	Motor mounts	IndianLocalShop
7	Cycloidal Drive Cam	ThinkRobotics
8	Cycloidal Drive output	Sharvi Electronics
9	Drive case screws	ThinkRobotics
10	Mount Screws	ThinkRobotics
11	Leg Screws	ThinkRobotics
12	Washers	IndianLocalShop
13	Spacers	ThinkRobotics
14	PLA	Robu

	Firing Mechanism	MAKE
1	60kg servo	Robu
2	Metal gear servo	Robu
3	Raspberry Pi Pico	Robu
4	MOSFET	Robu
5	RELAY	Robu
6	Gel gun	Amazon
7	LASER	Robu

	Bot	MAKE
1	Raspberry Pi 5B 8GB	Robu
2	LIDAR	Robu
3	FPV cam	Robu
4	VTX_CAM	Robu
5	HIGH-quality cam	Robu
6	Camera	Robu
7	BLDC motor	Alibaba
8	LCD-display	Robu
9	Teensey 4.1	Robu
10	Thermal IC	Robu
11	FOC driver	Robu
12	Battery 6s	Robu
13	IMU	Robu
14	Encoder	Robu
15	LORA	Robu
16	Esp Wroom 32	Robu
17	GPS 7M	Robu
18	Antenna GPS	Robu
19	Antenna Lora	Robu
20	SD card rasp	Sandisk
21	Telephoto lens	Robu
22	HXT connector	Robu
23	EYE connector	Robu
24	Transceiver CAN	Robu

II. List of Motion Components: like chains, sprockets, flaps, etc.

III. List of electronics components like smart pods, switches, joysticks, controllers, LED/LCD screen, power supply, and programming components

	ELECTRONIC COMPONENTS	**MAKE**
1	LCD display	Robu
2	Esp wroom 32	Robu
3	Raspberry Pi 5B 8GB	Robu
4	LIDAR	Robu
5	FPV cam	Robu
6	VTX_CAM	Robu
7	HIGH-quality cam	Robu
8	Camera	Robu
9	Teensey 4.1	Robu
10	Thermal IC	Robu
11	FOC driver	Robu
12	Battery 6s	Robu
13	IMU	Robu
14	Encoder	Robu
15	LORA	Robu
16	Esp wroom 32	Robu
17	GPS 7M	Robu
18	Antenna GPS	Robu
19	Antenna Lora	Robu
20	SD card rasp	Sandisk
21	Telephoto lens	Robu
22	Raspberry PI 5 Model B 4GB	Robu
23	SD CARD	Sandisk
24	LORA_antenna	Robu
25	LORA	Robu
26	Skydroid	Robu
27	Joystick	Robocraze

	ELECTRONIC COMPONENTS	MAKE
1	LCD display	Robu
2	Esp wroom 32	Robu
3	Raspberry Pi 5B 8GB	Robu
4	LIDAR	Robu
28	Potentiometer	Robu
29	Arduino WIFI MEGA	Robu
30	SPI Touch Screen	Robu
31	60kg servo	Robu
32	Metal gear servo	Robu
33	Arduino WIFI MEGA	Robu
34	MOSFET	Robu
35	RELAY	Robu
36	Gel gun	Amazon
37	Pulse-meter	Robu
38	GPS	Robu

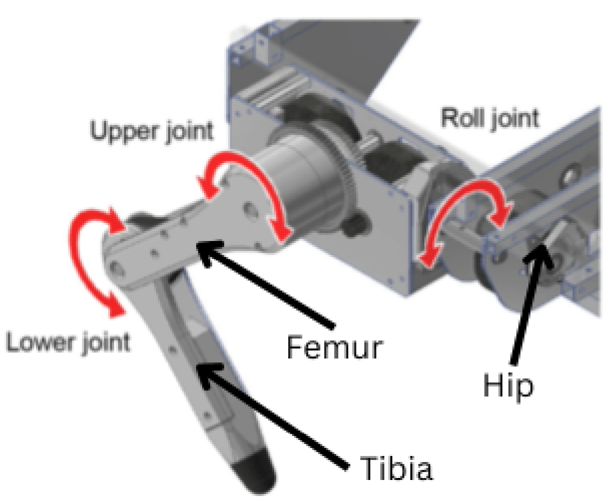
	REMOTE	MAKE
1	Esp-32-WROOM	Robu
2	TouchScreen HDMI	Thinkrobotics
3	Raspberry PI 5 Model B 4GB	Robu
4	SD CARD	Sandisk
5	LORA_antenna	Robu
6	LORA	Robu
7	Skydroid	Robu
8	Joystick	Robocraze
9	Potentiometer	Robu
10	Battery 2S	Robu

	SMARTWATCH	MAKE
1.	Esp-32-WROOM	Robu
2.	VibratingMotor	Robocraze
3.	Battery 1S	Robu
4.	SPI Touch Screen	Robu
5.	Pulse-meter	Robu
6.	GPS	Robu

4. The methodology of Making Robot: Please write technical specifications of the proposed Robot with brief notes and diagrams.

Mechanics

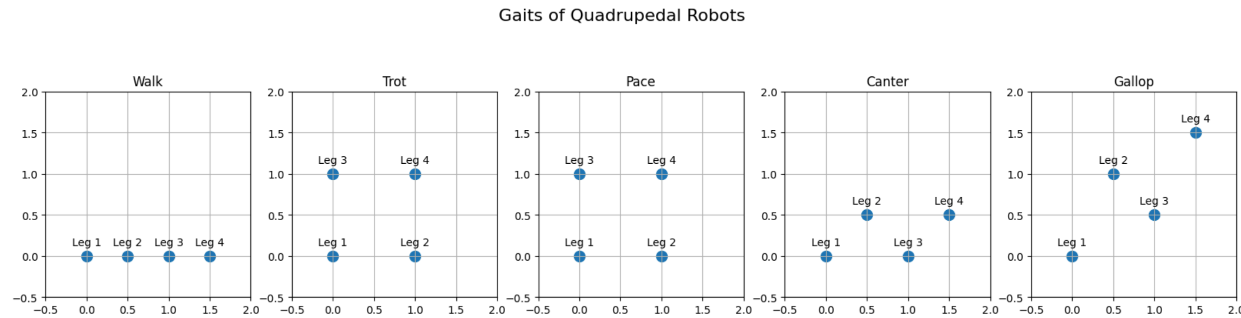
At its core, Dharma is a quadrupedal robot**,** engineered to move using four legs, similar to four-legged animals. It consists of a sturdy chassis with legs comprising multiple segments driven by high-torque actuators. The control system runs specialized algorithms, manages gait generation, and makes real-time adjustments. These robots offer unparalleled mobility, stability, and the capability to navigate rough terrain where wheeled robots falter.



In the structure of a quadruped robot's leg, the hip, femur, and tibia facilitate movement and stability. The hip joint is the connection point between the leg and the robot's body, allowing for a wide range of motion in multiple directions. The femur, analogous to the thigh bone in humans, extends from the hip joint to the knee joint, providing structural support and acting as a lever during locomotion. The tibia, also known as the shin bone, forms the lower part of the leg, connecting the knee joint to the foot pad. These components work

Fig. Different joint systems used in Dharma

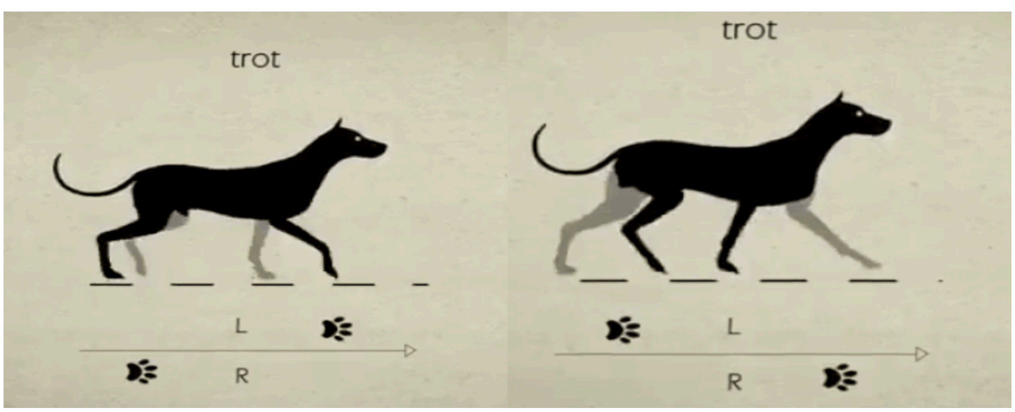
synchronously to execute various movements, including extension, flexion, and rotation, enabling the quadruped robot to navigate its environment with agility and precision.
Gaits in quadrupedal robots refer to the distinct patterns of leg movements used to achieve locomotion, each tailored to balance speed, stability, and energy efficiency.



Here is an illustration of the different gaits used by quadrupedal robots, demonstrating the distinct patterns of leg movements for each gait:

- **Walk -** sequential leg movement where each leg moves one at a time, providing high stability.
- **Trot** - diagonally opposite pairs of legs move together, balancing speed and stability.
- **Pace** - legs on the same side move together, resulting in lateral oscillations.
- **Canter** - a three-beat gait with one rear leg moving first, followed by a diagonal pair, and then the other front leg, allowing for faster movement.
- **Gallop -**: a four-beat gait with each leg hitting the ground separately, offering the highest speed but with less stability.

Each pattern is represented with positions for the legs, showing how the movements are coordinated in different gaits.



Dharma implements the **trotting** gait most commonly. The trot is a two-beat diagonal gait

Fig. Trotting of dogs

where diagonally opposite pairs of legs move together. When the front right leg moves forward, the back left leg moves forward simultaneously. Following this, the front left leg and the back right leg move together. This means the robot or animal has two legs on the ground at any given moment, providing stability and balance. The trot is more stable than faster gaits like cantering or galloping because two legs are always in contact with the ground, forming a stable base, has moderate speed, and is energy efficient. Trotting has two phases. The stance phase involves the legs in contact with the ground, providing support and propulsion. For each diagonal pair, one leg in the pair remains on the ground longer than the other to ensure continuous support. The swing phase involves the legs being lifted off the ground and moved forward to the next position. The diagonal pair swings simultaneously, preparing for the next stance phase.

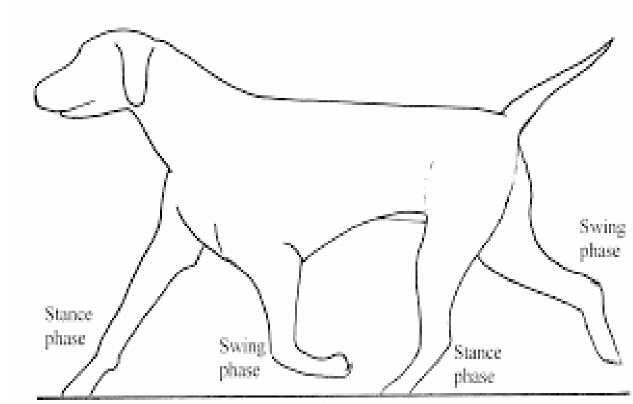
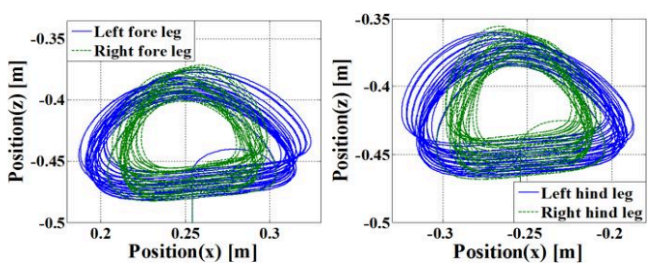


Fig. Trotting phases

During the trot gait, the movement of the one-foot pad of a quadrupedal robot follows a rhythmic pattern characterized by alternating phases of lift-off, forward swing, and ground contact. As the robot advances, the foot pad initially lifts off the ground, propelled upward by the robot's forward momentum. Subsequently, it swings forward in an arc motion, positioning itself for the next ground contact. Upon reaching its forwardmost position, the foot pad then makes contact with the ground, providing support and stability as the robot transfers its weight onto it. This contact phase serves to propel



(a) Trajectorys of fore legs (b) Trajectorys of hind legs

Fig. 21. Trace of foot trajectory

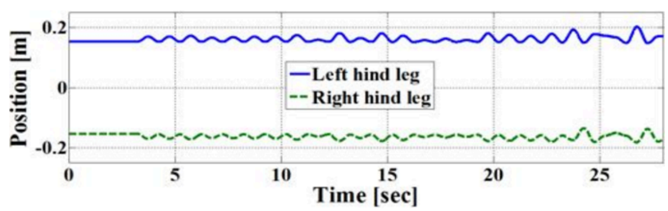


Fig. Graphical representation of trotting

the robot forward while also absorbing shock and ensuring traction. Meanwhile, the other three feet undergo similar cyclic movements in coordination, collectively facilitating a smooth and efficient trotting gait for the robot.

Dharma archives this complex motion with a 12 degree of freedom, 3 DOF per leg, with the help of 12 cycloidal drives, 3 cycloidal drives per leg, one for the hip, one for the femur, and one for the tibia.

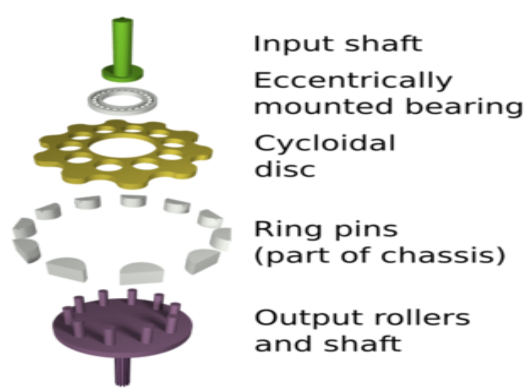
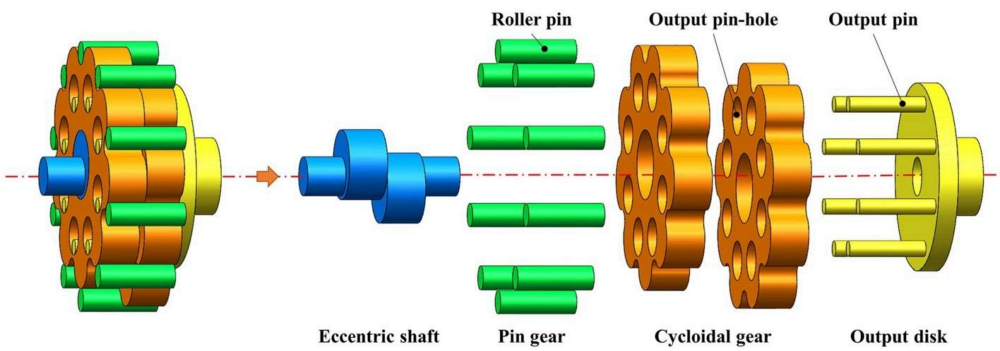


Fig.

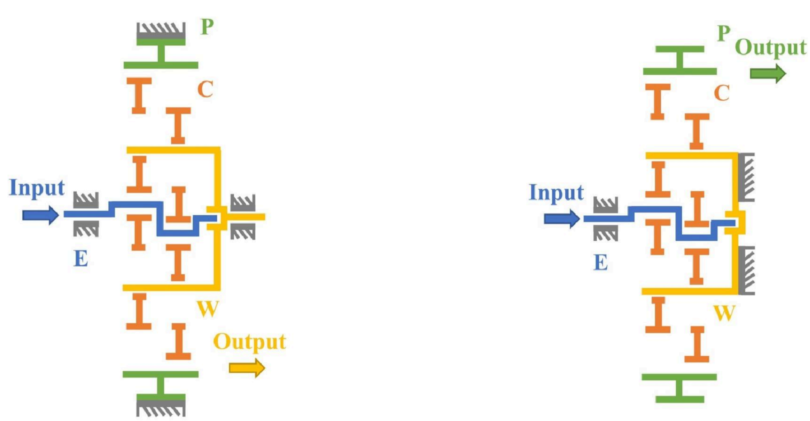
Fig. Parts of cycloidal

Cycloidal drives are a high-performance precise transmission technology characterized by compact size, rigidity, high reduction ratio, and high load capacity. They have been extensively employed in various industrial fields, particularly heavy-duty machinery, mining, machine tools, and industrial robots that demand high load capacity and precision transmission. In robotics, cycloidal drives are often utilized as RV reducers to construct robot joints with high precision, rigidity, and load capacity. Moreover, recent robotic research has revealed that due to the cycloidal drive's high reduction ratio, impact resistance, and efficiency, it is also suitable for a wide range of new compliant robots, such as collaborative robots, exoskeleton robots, and legged robots.

Cycloidal drives are essentially specialized planetary transmissions that utilize a pin gear as the internal gear, cycloidal gears as the planetary gears, and a planetary carrier in the form of an eccentric shaft as the power input. Various studies have derived the ideal cycloidal gear tooth profile equation using different methods. In an ideal cycloidal drive, all roller pins contact the cycloidal gear, and about half the roller pins bear the load. The teeth in the pin gear are typically designed as a rolling structure (roller pins) to transform the sliding friction of tooth contact into rolling friction, thereby improving transmission efficiency. However, cycloidal gear transmissions often require intentional clearance design due to manufacturing deviations, thermal deformation, lubrication, and assembly. Furthermore, limitations in machining accuracy can give rise to minor geometric parameter deviations, which also lead to clearances.



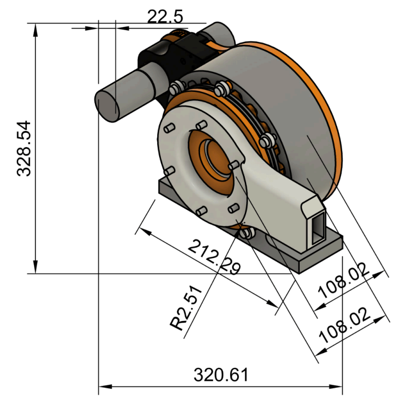
A typical cycloidal drive consists of four key components: an eccentric shaft, cycloidal gears, a pin gear, and an output disk. Typically, the eccentric shaft serves as the input shaft with an eccentricity distance *e*. The cycloidal gear employs a curtate epicycloid tooth profile; two cycloidal gears are often symmetrically arranged for dynamic balance. The pin gear comprises evenly spaced roller pins. The output disk, which transmits the rotational motion of the cycloidal gear, can assume various designs. A widely adopted configuration is the output pin structure, where the pin-holes on the cycloidal gear align with the

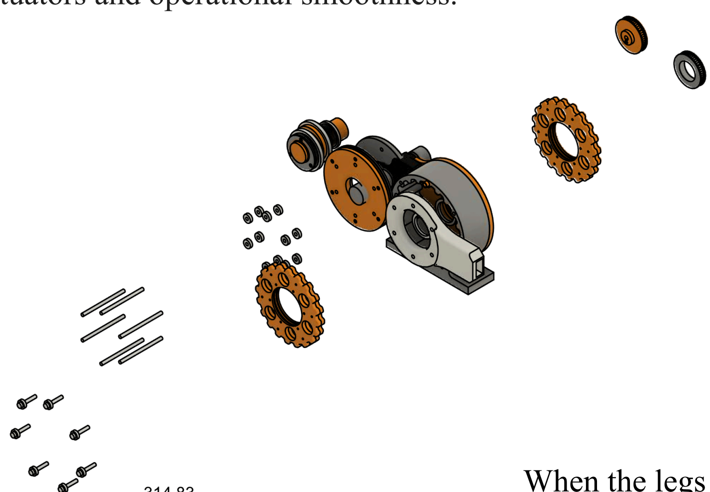


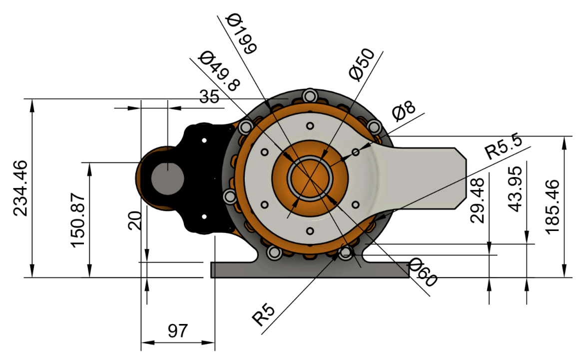
same distribution radius as the output pins on the output disk.

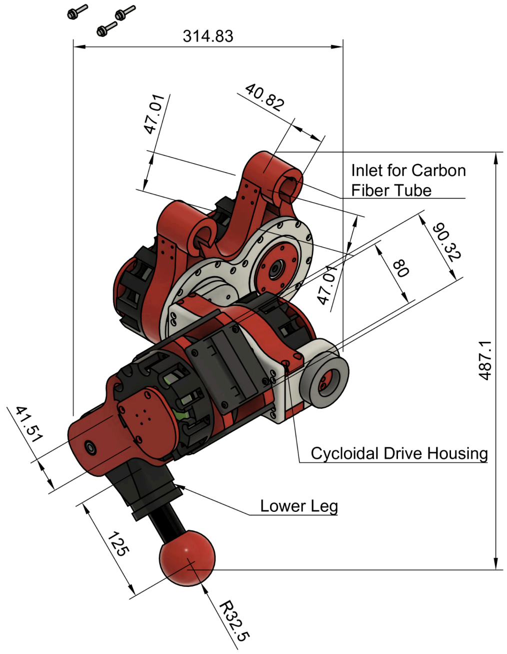
In practical applications, the output disk is not always used as the power output. When the cycloidal drive is configured with configuration A, “pin gear fixed, output disk outputs”. When the cycloidal drive is configured with configuration B, “output disk fixed, pin gear outputs”. Dharma uses cycloidal drives with configuration A to provide precise control

The cycloidal drive mechanisms within the framework of Dharma follow the characteristics of outer disk power output drives. In the context of prototyping, these mechanisms are to be fabricated utilizing 3D printing, employing polylactic acid (PLA) as the primary material through the process of fused deposition modeling (FDM). Furthermore, the purpose of adding ball bearings is to increase the power transmission efficiency from the planar brushless direct current (BLDC) motors to the articulated joint actuators. This will guarantee a significant increase in power transmission to the joint actuators and operational smoothness.





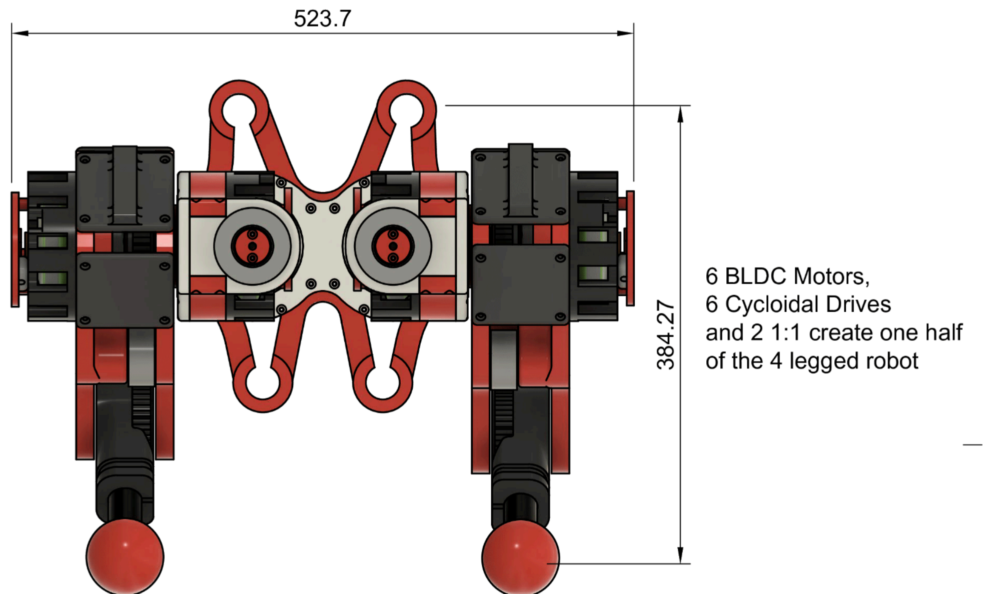


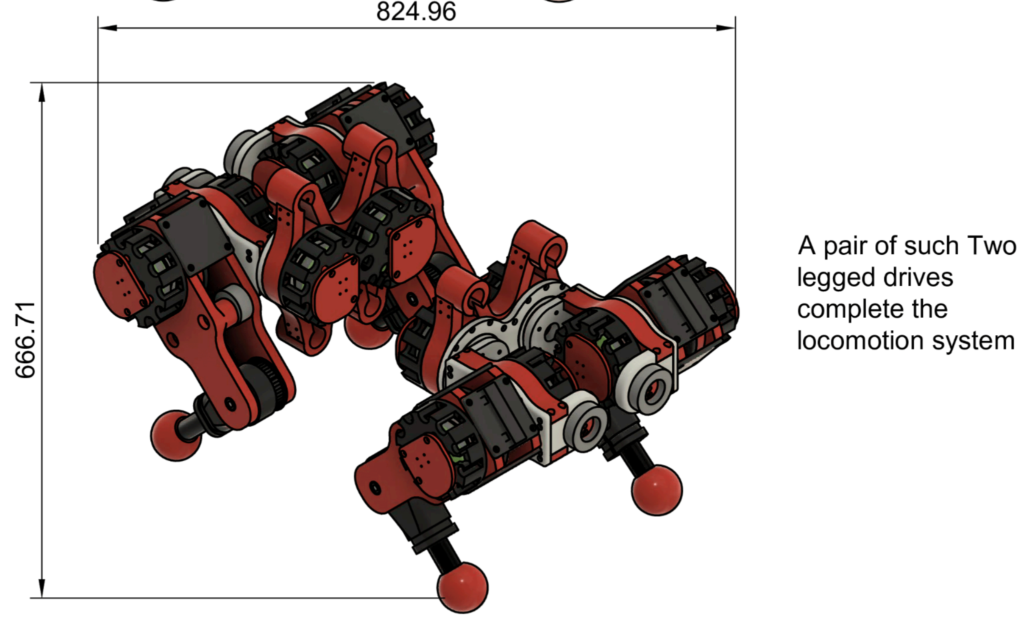


When the legs are in the closed loop state, this mechanism makes sure that they have an inherent spring quality that allows them to quickly revert to their original configuration if an external force causes deformation. This inherent feature serves to auto-correct deviations, thereby reinstating the limbs to their intended positions during locomotion. Moreover, the system functions akin to shock absorbers, adeptly attenuating external perturbations. Moreover, the system functions similarly to shock absorbers, adeptly weakening external disturbances.

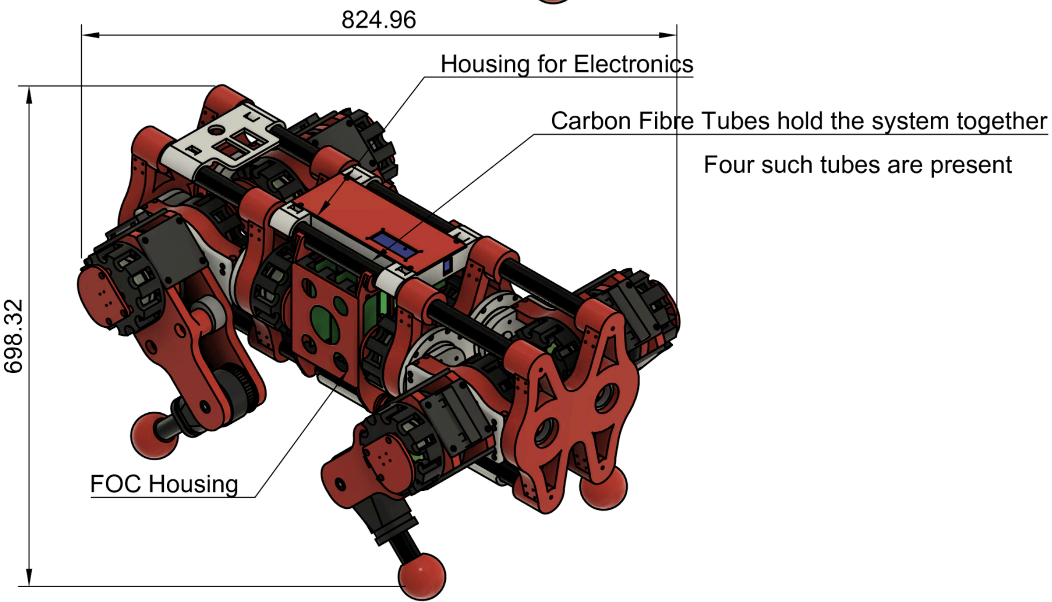
Moreover, it is capable of rectifying minor discrepancies faced during the regular continuation of the locomotive algorithms, thus refining the movement in practicality.

A cycloidal drive facilitates movement of the entire leg in one degree of freedom through the hip joint, joining the leg to the body of the quadruped. Another cycloidal drive gives the femur, the upper leg, a rotational range of freedom of one degree, and the last cycloidal drive connects with the tibia through a 1:1 belt transmission, giving the tibia, the lower leg, another degree of freedom. With three BLDCs transmitting power through three cycloidal drives, the leg drive system has a total of three degrees of freedom.



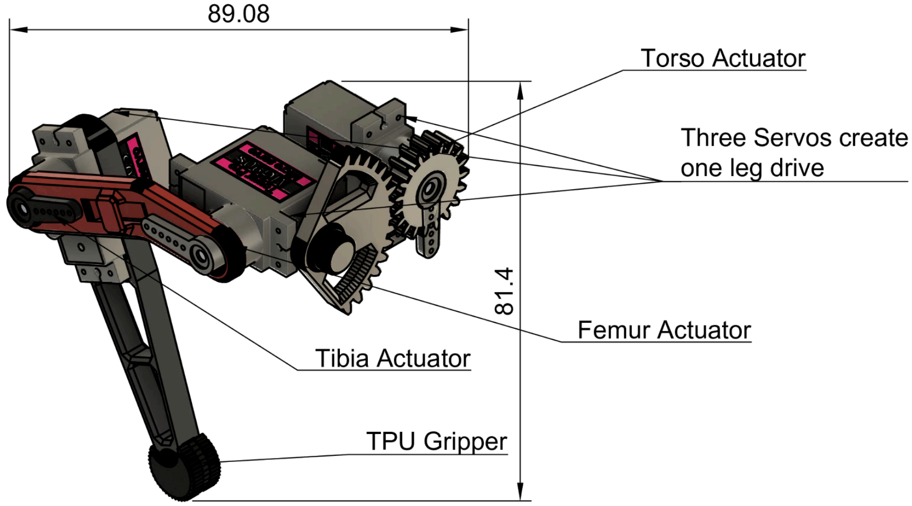


Two of the single-leg drives come together to form one side of the quadruped, held in place by an X-shaped end face that also houses holes that would let carbon fiber tubes slide into them, attaching them to the main body. Two of these halves form the entirety of the locomotive units of the quadruped robot, giving it 12 degrees of freedom, 3 in each leg.



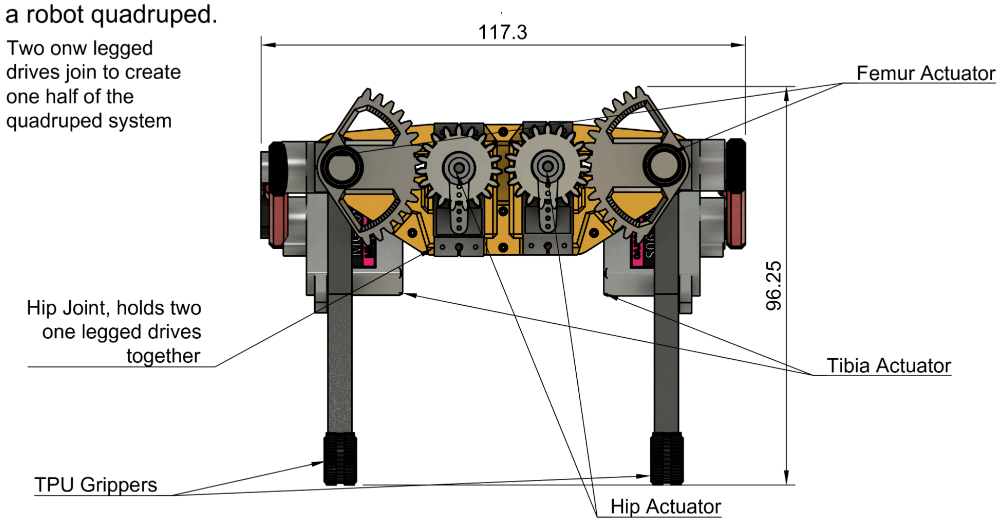
The Prototype

This prototype proves the concept that lays the foundation for the entire working mechanism of the Dharma Quadruped robot. To achieve this, the smaller model showcases the trotting gait of Dharma quadrupled using servos and a singular control unit. This smaller Dharma model is a stipend-down version of the original Dharma quadruped and lacks all the precise control and power transmission systems of the proposed final model, which utilizes BLDC motors, FOCs, and encoders to achieve them. Instead, it keeps costs low and yet archives the target of showcasing the trotting gait of a mammalian quadruped using the bare minimum of metal-gear micro-servos.

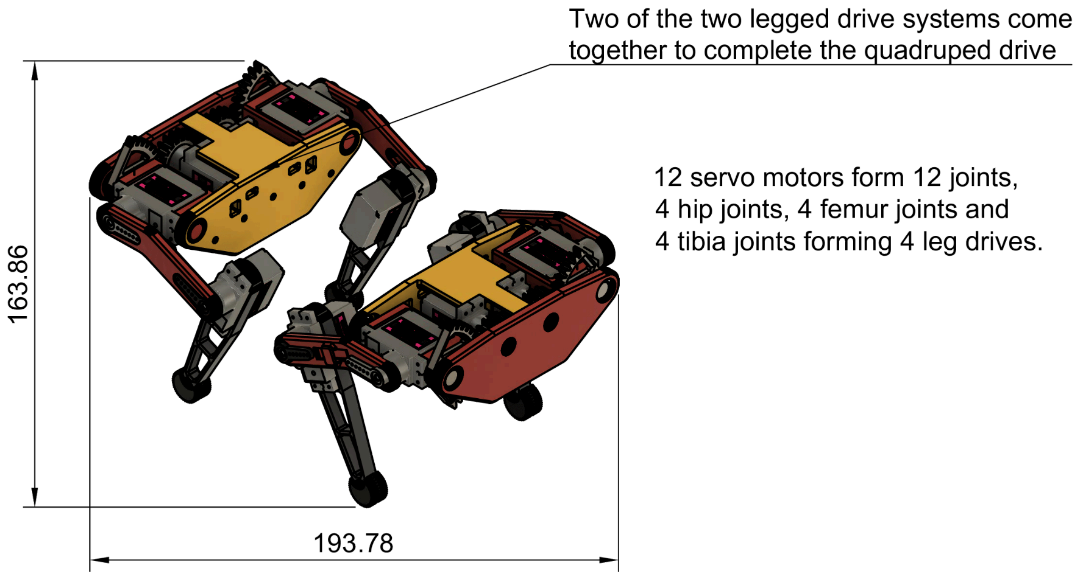


Three servos take the place of three BLDC motors, which facilitate the movements of the hip, the femur, and the tibia joints, achieving the 3 DOF required to mimic quadruped mammals.

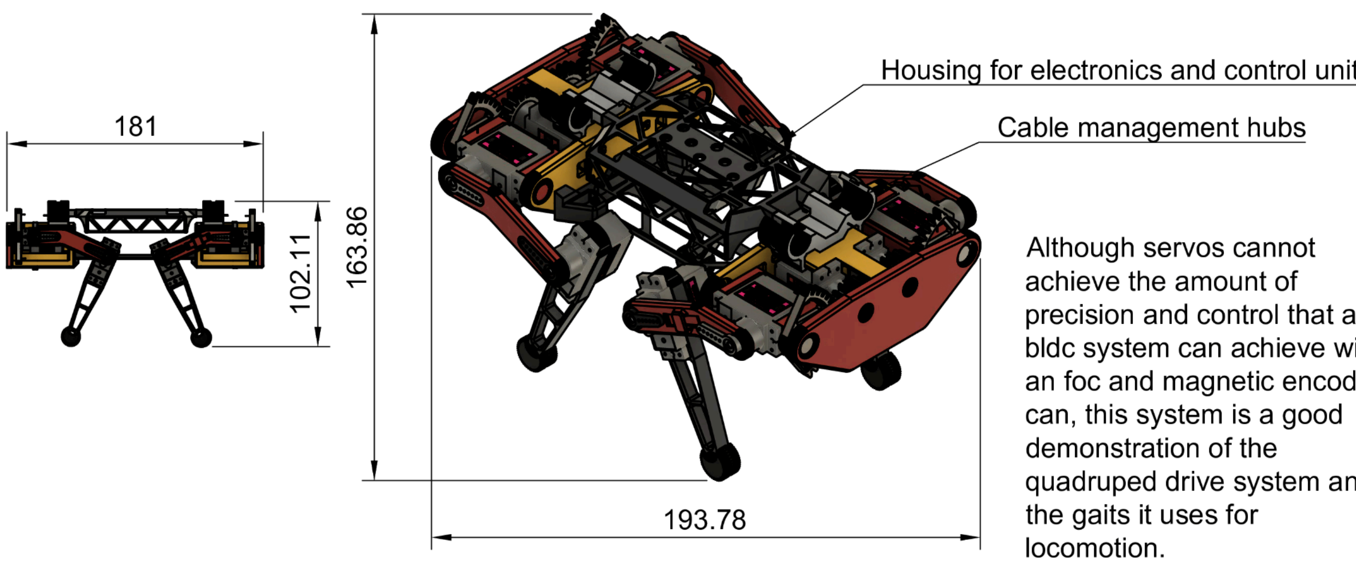
A simpler servo based prototype of a cycloidal drive based one leg drive system of a robot quadruped.



Two of these one-legged drive systems form one-half of the robot, driven by 6 servos and a pair of legs, hips, femurs, and tibias, achieving 6 degrees of freedom.



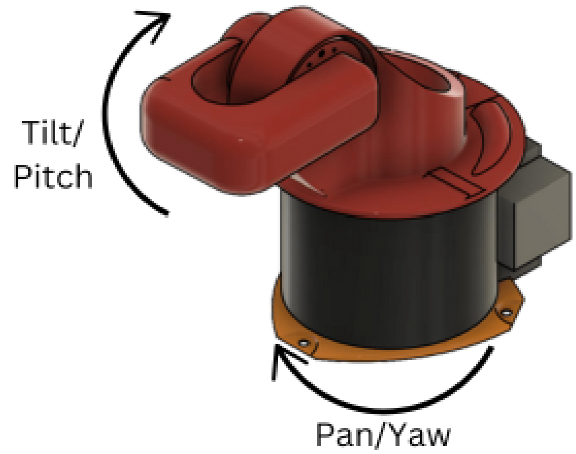
These two halves thus complete the entire locomotory set of drives required to achieve mimicry of mammalian quadruped movement through the trotting gait.



Although servos cannot achieve the amount of precision and control that a bldc system can achieve wih an foc and magnetic encoder can, this system is a good demonstration of the quadruped drive system and the gaits it uses for locomotion.

Turret

The turret system, mechanically, is a simple 2-degree-of-freedom rotatory base attached to a rotatory shoulder that houses a firing weapon. Two servos, one attached to the base and one to the shoulder, provide pan and tilt actions, also known as pitch and yaw, letting the firing mechanism aim at a target. The cameras' data is processed and converted into a set of instructions that cause servo rotations, which in turn aim the firing mechanism's muzzle in the direction of the target. Two ball bearings are attached, one at the base and one at the shoulder attachment, to smoothen the movement of the turret system.



Electronics

Dharma, the Robot Dog, is composed of three electronically independent subsystems: the bot itself, a smart remote for control, and a smartwatch as a peripheral device. These subsystems are interconnected through a common network, each crucial in ensuring Dharma's functionality, ease of use, and versatility. Together, they form a cohesive system that enhances the robot's performance and user experience.

Smart Watch

The smartwatch integrates an ESP-32-WROOM microcontroller, an SPI touchscreen display, a pulse-meter sensor, and a GPS sensor as its primary components. This system enables users to access and utilize crucial information through the ESP-32, facilitating the selection of various modes such as, and others via the GUI interface on the touchscreen.

For additional safety, the device includes two physical buttons that allow for manual selection and toggling of options on the screen. This ensures that critical commands can be executed even if the touchscreen becomes unresponsive, providing a reliable backup control method.

The touchscreen displays comprehensive information about connectivity status, enemies detected, the bot's location, and other combat-related data. This ensures that the user has all the necessary information at a glance, significantly enhancing situational awareness and decision-making capabilities in dynamic environments.

Key features of this system include geotag deployment and a heart-beat checking system. The pulse-meter sensor displays the wearer's heart rate and also functions as a failsafe mechanism. In military mode, if the pulse reads zero for more than 30 seconds, the system will shut down and lock with a password, ensuring the user's safety and preventing unauthorized use. Additionally, if the system is activated abruptly, a kill switch can be pressed to return the device to normal operation, adding an extra layer of control.

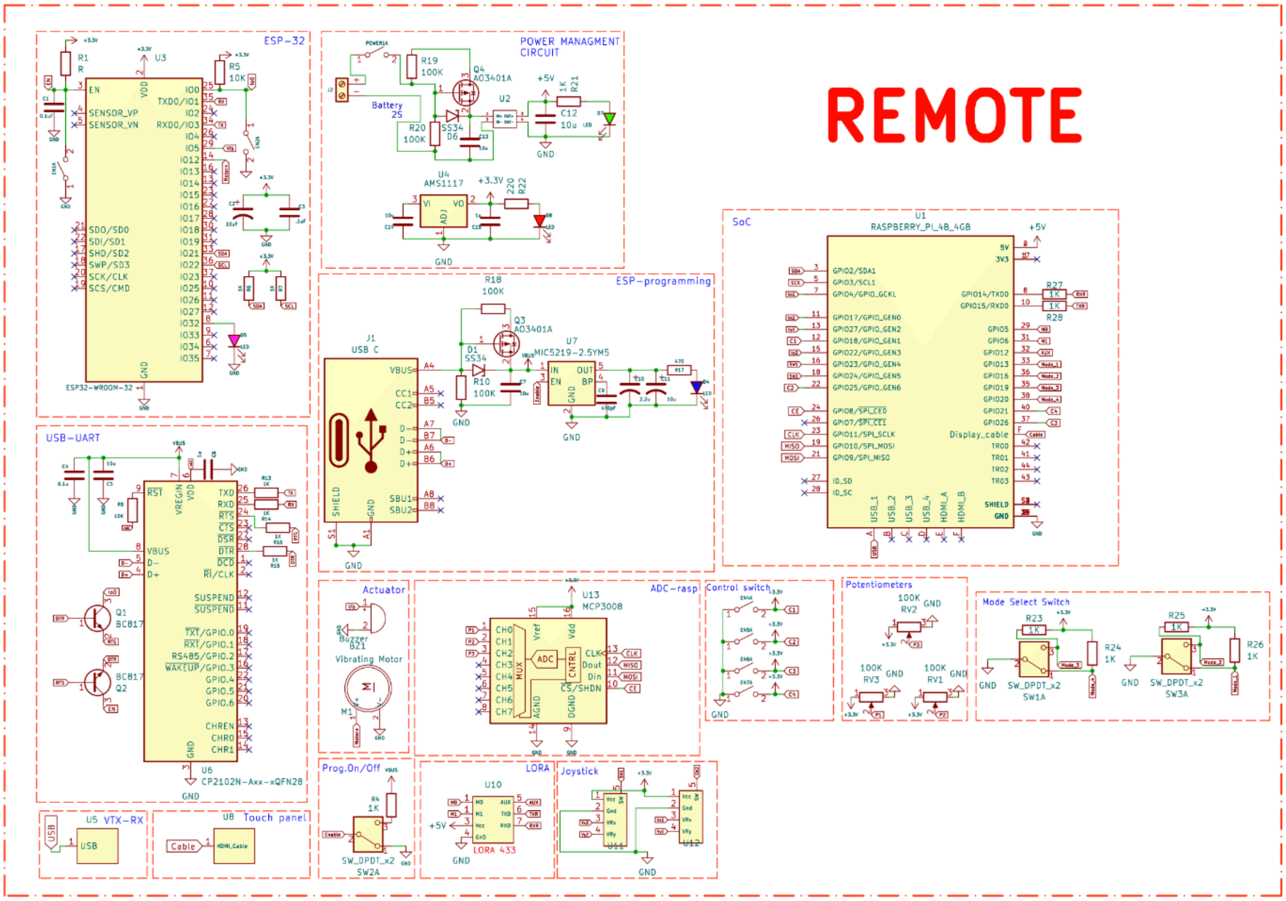
Thus, when the military mode is activated, the ESP immediately sends the current location of the watch to the remote. This data is then treated as an interrupt, triggering an immediate transmission of the information to the control center. This ensures that critical location data is promptly relayed, enhancing situational awareness and coordination in high-stakes scenarios.

The geotag deployment feature, detailed later in the documentation, records the number of deployed tags and their GPS locations. This capability is vital for tracking and operational planning, providing precise geospatial information is crucial for mission success.

The smartwatch, acting as a peripheral, is connected to the smart remote via the ESP-NOW protocol. This protocol, developed by Espressif, offers a fast, encrypted wireless network, ensuring secure and efficient communication between devices. This connectivity ensures seamless integration and real-time data exchange, enhancing operational efficiency.

Additionally, the smartwatch is equipped with actuators, such as a buzzer and a vibrating motor, to provide tactile feedback to the wearer. This feature enhances the user experience by offering immediate alerts and confirmations for various actions, ensuring the user is promptly informed of any critical updates or commands.

The entire system is designed on a custom PCB board, which includes a programming chip and a power management system. This integrated design ensures reliable performance and ease of maintenance, making it suitable for both field operations and regular use. The robust design and comprehensive feature set of the smart remote extension make it a versatile and indispensable tool for enhancing control and operational efficiency with ease.



Smart Remote

The smart remote serves as the central control hub for the entire system, governing the full functionality of the bot. Its hardware configuration includes a potent Raspberry Pi,, a 7-inch HDMI touchscreen for intuitive interaction, an ESP-32 WROOM module, a LoRa module for long-range data transmission, and an FPV receiver module for streaming live footage. This amalgamation of cutting-edge components forms the backbone of the remote, enabling seamless operation and comprehensive control over the bot's actions.

LoRa Communication

To establish robust communication links, the smart remote is integrated with an SX1278 433MHz LoRa module. This module, operating via the UART communication protocol, serves as the conduit for data exchange between the remote, the control center, and the bot itself. Operating within a radius of 1km in manual mode, its capabilities extend to a staggering 10 km with antennas, ensuring uninterrupted communication across vast distances.

ESP-NOW Communication

The smart remote houses an ESP-32 WROOM module dedicated to communication with the smartwatch. This module facilitates the seamless exchange of vital information such as mode selection, combat data, and the wearer's status updates. Notably, the ESP-32 WROOM features an ingenious failsafe mechanism triggered by abnormal wearer conditions. In the event of an emergency, this mechanism sends the smartwatch's location to the control center while simultaneously securing the remote to prevent unauthorized access, a feature aptly named the FailSafe mechanism.

High-Quality Streaming

The remote's capability to stream high-quality video from the bot's onboard camera is a testament to its advanced functionality. By interfacing with the Raspberry Pi on the bot, the remote harnesses the power of its high-resolution camera, delivering crisp video feeds through a shared access point. This seamless integration enables real-time visualization of critical information, including machine learning algorithms and recognition processes, empowering users with unparalleled situational awareness.

FPV Streaming

For extended-range applications, the smart remote is equipped with an FPV streaming system, providing a live video feed from the bot's FPV camera. Through a VTX (video transmitter) and receiver setup, the remote captures and displays live footage with a range of up to 1 km. Leveraging USB connectivity to the Raspberry Pi, the remote effortlessly extracts and processes video signals, ensuring uninterrupted transmission of vital visual data.

GeoTag

The implementation of GeoTags enhances situational awareness and facilitates swift response to critical scenarios. When the bot identifies an injured soldier through computer-aided vision, it promptly transmits the precise location to the remote. This location data, comprising latitude and longitude coordinates, is seamlessly integrated with the Google Maps API, providing real-time visualization to both the remote user and the control center. This enables rapid deployment of rescue operations to the exact location, bolstering operational efficiency and ensuring timely assistance to personnel in distress.

GUI Interface

A user-friendly GUI interface serves as the cornerstone of seamless interaction with the smart remote. Offering a systematic layout, this interface grants users access to an array of features, from manual mode control to autonomous operations and from sensor data to live camera feeds.

Its intuitive design simplifies navigation, empowering users with comprehensive control over the bot's actions and functionalities.

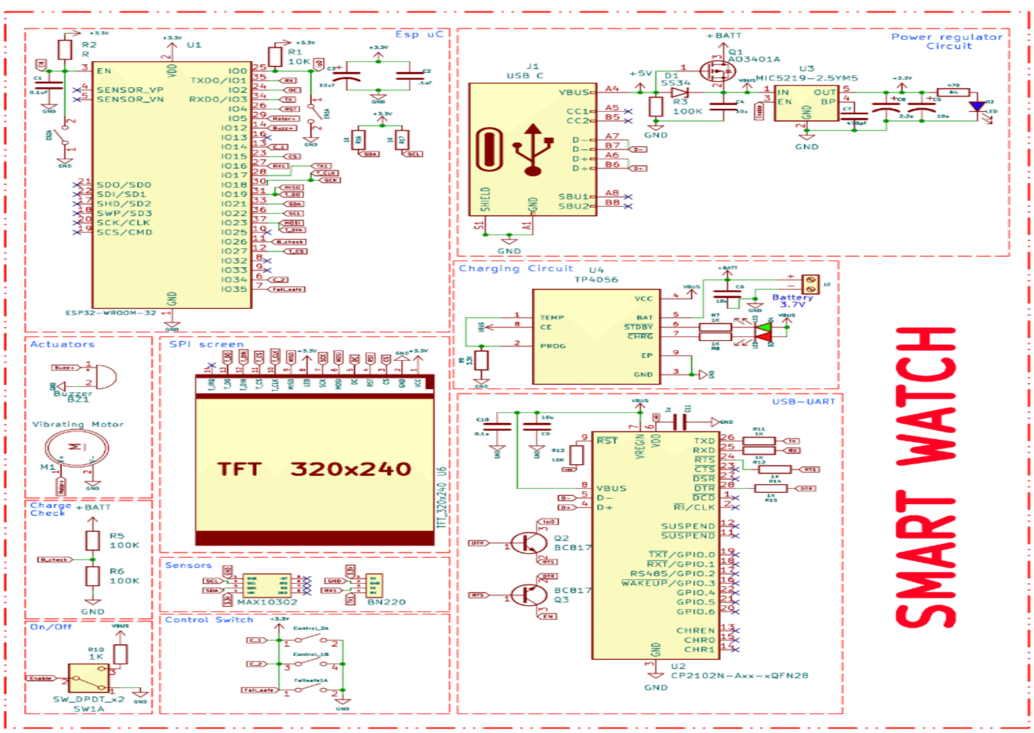
Manual Modes

Incorporating tactile, toggle switches, and potentiometers, the manual mode control interface provides users with tactile feedback and precise control over the bot's locomotion and firing systems. Joysticks and potentiometers offer intuitive control, while tactile switches serve as fail-safes in case of touchscreen unresponsiveness. Toggle switches facilitate seamless mode selection, adding an extra layer of control and versatility to the user experience.

GPS Back-to-home

The GPS back-to-home feature ensures the safe return of the bot to its designated starting point or the wearer's location, depending on the scenario. Leveraging GPS data from the smartwatch, the bot autonomously navigates to the specified destination, ensuring efficient deployment and retrieval in various operational contexts.

The entire system is meticulously crafted on a custom PCB board, housing a programming chip and a sophisticated power management system. This integrated design not only ensures reliable performance but also facilitates ease of maintenance, making it ideal for both field operations and routine use. The comprehensive feature set and robust design of the smart remote extension elevate its status as an indispensable tool for enhancing control and operational efficiency in diverse scenarios.



Main BOT(Body)
The main body of the system comprises a Raspberry Pi 5 GB, Teensey 4.1 microcontroller, FPV system, 2 Raspberry cameras, LORA, LIDAR, FOC driver, and a GPS module. This comprehensive setup is divided into several subsystems, each serving a specific purpose:

BLDC Control and FOC
The system has 12 BLDC controls and 6 FOC (Field-Oriented control) systems. The FOC driver is a specialized BLDC motor driver designed to utilize encoders for precise feedback. It employs sophisticated algorithms to ensure the efficient and smooth operation of the brushless DC motors.

The FOC driver integrates a microcontroller, power stage, and encoder feedback mechanism, enabling precise control over motor speed, position, and torque. This level of control is crucial for applications requiring high-performance motor control in compact environments. The FOC driver used in the system features dual motor control and includes its own microcontroller with CAN communication capability, allowing it to function as a slave device controlled by another microcontroller.

To provide precise rotational information to the FOC board, magnetic rotary encoders are employed. These encoders accurately measure the rotation of the motors, enhancing the overall control and performance of the system.

The locomotion of the bot is primarily driven by the Teensey 4.1 microcontroller, which connects all six FOC drivers. The Teensey serves as the central controller for motor control, interfacing with the IMU unit and the Raspberry Pi of the bot through I2C communication. In this setup, the Teensey acts as a slave device, while the Raspberry Pi serves as the master, commanding the autonomous system configuration and providing information on the bot's motor orientation based on the Robot Operating System (ROS) simulation.

By effectively integrating these subsystems and leveraging advanced control algorithms, the system achieves precise motor control and seamless coordination between various components, enabling efficient and reliable operation in diverse environments.

The FPV Cam System
It is a system that provides FPV capabilities for the bot. This subsystem comprises an FPV camera and a VTX, forming a completely independent system dedicated to long-range FPV viewing.
The FPV camera captures live footage of the bot's surroundings, allowing operators to remotely visualize the environment in real-time, this ensures seamless communication between the bot and

the remote control, enabling operators to monitor the bot's movements and surroundings from a large control radius, even from the remote control station.

High-quality Camera Feed System

The system incorporates a High-Quality Raspberry Pi Camera sensor equipped with a Telephoto Lens, providing enhanced imaging capabilities for comprehensive visual data acquisition. The camera feed captured by this sensor is mirrored to a local network through a designated IP address, facilitating seamless transmission and accessibility of the visual data.

On the receiver side, the remote's Raspberry Pi serves as the interface for displaying the received feed. By connecting to the same local network, the remote Raspberry Pi can access and display the camera feed in real time. This setup ensures efficient communication and visualization of the captured data between the sender and receiver components of the system.

The transmitted feed contains valuable information about image recognition, scouting activities, face detection, and other computer-aided vision data processed by machine learning algorithms with integrated situational awareness and decision-making capabilities.

The displayed feed showcases high-quality imagery, ensuring clarity and precision in the visual representation of the surroundings. This enables operators to analyze the captured data with accuracy and confidence, facilitating effective navigation, surveillance, and operational planning in diverse environments.

Firing System

The firing system comprises three 60 KG servos directly connected to the Raspberry Pi Pico. These servos are responsible for controlling the firing mechanism of the system.

The secondary camera is utilized for image recognition purposes. Through the image recognition model, the firing system identifies specific targets or objects to engage.

The Pico serves as the central controller for the firing system. It receives commands and data from the image recognition process and coordinates the actions of the servos accordingly.

To facilitate communication between components, the Pico is connected to the Raspberry Pi via the I2C protocol. This connection enables seamless data transfer between the two devices, enhancing the overall functionality and coordination of the firing system.

Upon recognizing a target, the Raspberry Pi sends relevant data, such as Degrees of Freedom (DoF), and other necessary information to the Pico.

Using this data, the Pico triggers the appropriate servo motors to activate the firing mechanism, engaging the identified target effectively and accurately.

This methodology ensures efficient and precise operation of the firing system, enabling it to engage targets based on real-time image recognition data while maintaining seamless communication. Thus, every detection and firing information is then sent to the remote and control station by the communication system.

Communication System

The system utilizes two communication systems to facilitate seamless data exchange: a local network using Raspberry Pi and LORA for long-range communication.

The Raspberry Pi serves as a communication hub within the local network, enabling efficient transmission of data between the remote and the bot. It facilitates the real-time exchange of information such as sensor data, mode selection, and other critical updates related to combat and vision processing.

On the other hand, LORA (Long Range) communication provides a robust solution for long-distance data transmission between the remote, control center, and other remote locations.

LORA is integrated into the remote and serves as a reliable medium for transmitting essential information, including mode selection, manual control, enemies detected, and sensory input, over extended distances.

This dual communication setup ensures comprehensive coverage and reliable connectivity across various operational scenarios, allowing for seamless coordination and exchange of critical data between different system components and remote locations.

IMU system

The system incorporates an MPU-9225 sensor, which is integrated into the Teensey 4.1 system using I2C communication. This sensor plays a pivotal role in the implementation of PID control and obtaining orientation and degrees of freedom data for the bot.

Utilizing the I2C communication protocol, the MPU-9225 sensor interfaces with the microcontroller, establishing a reliable connection for real-time data exchange from the sensor, including accelerometer and gyroscope readings.

The sensor captures data related to the bot's orientation and movement through its accelerometer and gyroscope components, providing valuable insights into the bot's spatial orientation, velocity, and angular velocity, essential for precise control and navigation.

GeoTag Deployment

The GeoTag deployment feature represents a unique implementation of GPS technology integrated within the bot. Utilizing the primary camera used for human image recognition, the system identifies injured individuals. Upon detection, the system promptly retrieves the geographical positions of these individuals.

This positional data is then transmitted to both the remote and the central control center through the communication unit

Subsequently, further data processing occurs inside the remote and then facilitates immediate rescue operations for the identified individuals, ensuring swift and efficient response to critical situations.

Sentri Mode

Sentri Mode involves the bot remaining stationary in a fixed position while scanning for enemies. It can engage targets using either auto-fire or manual controls.

Scout Mode

Scout Mode, on the other hand, entails the bot accompanying the controller person, essentially functioning as a military dog. It walks alongside the controller, providing support and surveillance. Similar to Sentri Mode, it can utilize either auto-fire or manual controls when engaging targets.

Autonomous Firing Mode

The firing mechanism is employed to engage targets detected by a previously discussed algorithm. When an enemy is identified, the system activates the firing mechanism to neutralize the threat. This mechanism operates based on predefined parameters and algorithms, ensuring precise and effective targeting. Once the target is confirmed, the firing mechanism executes the necessary actions, i.e..., activating weaponry, to eliminate the threat.

Manual Firing and Locomotive Mode

In manual control mode, the bot is operated manually using the remote's joystick and potentiometer controls.

This mode resembles controlling an RC robot dog, where all actions are performed manually, including firing, moving forward and backward, and other maneuvers. Users have direct control over the bot's movements and actions, allowing for precise navigation and interaction in various environments.

Manual control mode offers flexibility and real-time responsiveness, making it suitable for situations that require immediate adjustments or fine-tuned movements.

LiDar Mapping

The TF Mini LiDAR sensor is employed for obstacle avoidance by mapping the surrounding area and preventing collisions. This sensor is mounted on a rotating servo motor that sweeps from 0 to 180 degrees and back, continuously scanning the environment.
in front of the bot, detecting obstacles within its range.
As the servo motor rotates, the LiDAR sensor takes distance measurements at various angles, these distance readings are recorded at regular intervals, creating a series of data points that represent the distance to the nearest object at each angle.

The collected distance data is processed to create a 2D map of the surroundings.
This map shows the positions of obstacles relative to the bot, providing a clear view of potential collisions.
Thus, when an obstacle is detected within a certain distance threshold, the control system adjusts the bot's trajectory to avoid a collision.

The LiDar is operated using the UART protocol, thus, LIDAR is connected to the Raspberry Pi Pico, and then Pico is connected to the Raspberry and Teensey using the I2C protocol.

Display

A simple I2C display is utilized to indicate the active mode of the dog.

This display provides clear feedback regarding the current operational mode, ensuring they are aware of the bot's behavior and capabilities at all times.
By displaying the mode on the I2C screen, users can quickly identify whether the bot is operating in Sentry, Scout, Follow, or any other mode selected.

Back-to-home

The failsafe protocol is enabled by the remote controller. Once enabled, the bot has two potential return locations. If the bot needs to return to the launch site, it will navigate back to the location where it was first launched in the mission. Alternatively, if the bot needs to return to the controller's location, the location of the controller is determined by the watch worn by the controller. This location information is then transmitted from the watch to the remote controller, and the remote controller relays this location information to the bot via the communication system. Based on the received location, either the launch site or the controller's current position, the bot navigates to the specified location. This ensures the bot returns safely according to the enabled failsafe protocol.

KillSwitch

It is a safety protocol incorporated into both the bot and the firing mechanism to ensure safety in the event of abrupt behavior. If the bot or the firing mechanism starts to behave unexpectedly, the killswitch is to be pressed, and it will immediately halt all operations, thereby preventing potential harm or damage. This protocol provides an essential layer of security by allowing for the rapid shutdown of the system in emergencies.

Control Centre

The system comprises an Arduino and a LoRa module, which are responsible for receiving signals from both the bot and the remote. These components establish communication between the bot and the remote control unit. The control system designed will be a small base unit that will represent the base station that the user might want to contact during active deployment in a warzone to establish the connection to relay intel.

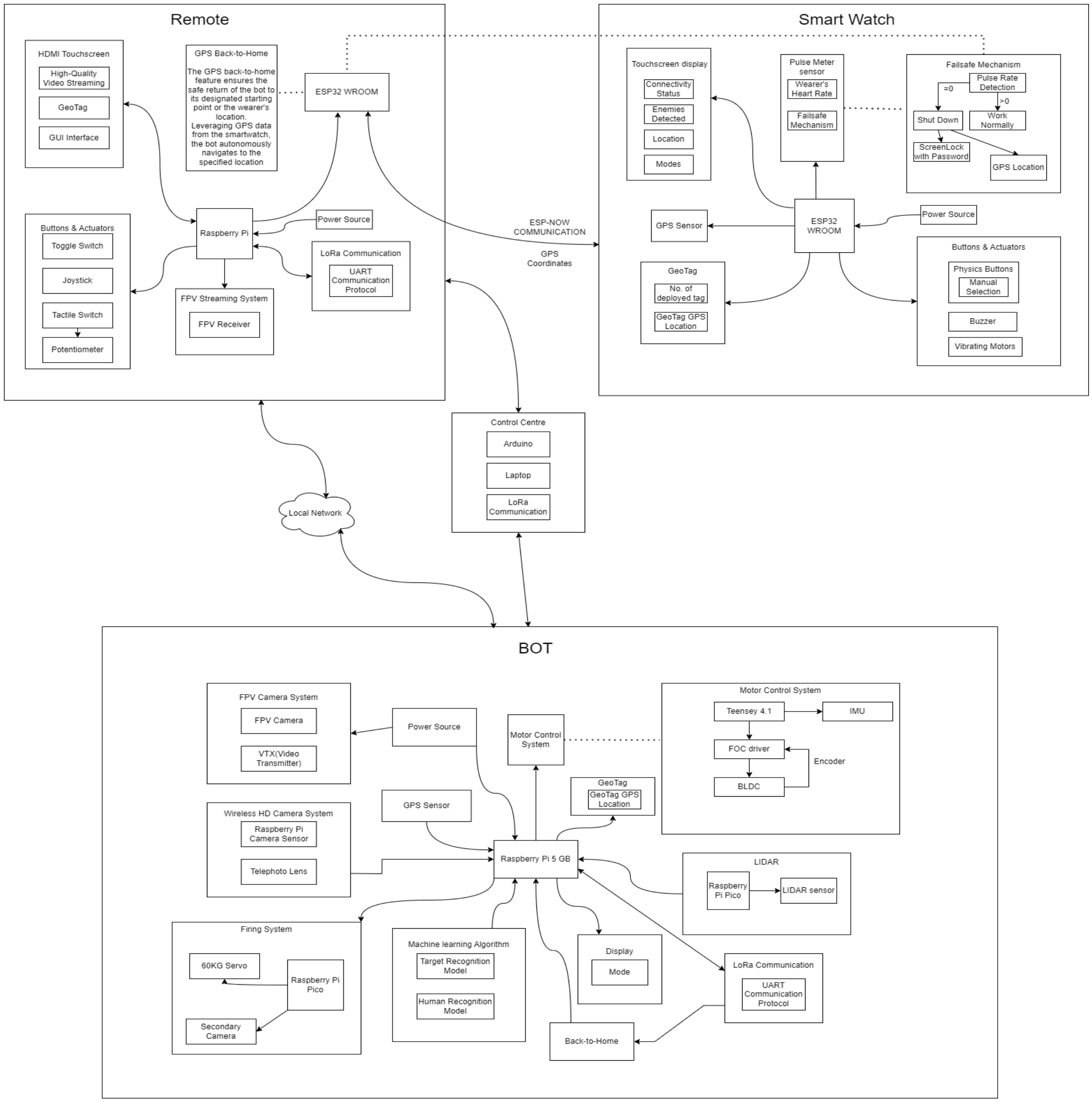


Fig. Flowchart to describe the whole procedure

Prototype

In the prototype, there is a system designed to utilize sensor input for controlling servos connected to it. The system is built around an ESP-32, which serves as the main computing board. The ESP-32 processes inputs and controls outputs efficiently, making it ideal for this application. To handle the voltage level conversion, the system incorporates a logic level converter IC. This IC converts the 3.3V signals from the ESP-32 to 5V, which is necessary for generating proper PWM signals for the servos.

The servos themselves are connected to a dedicated servo board. This board interfaces with the ESP-32 via an I2C communication protocol, ensuring smooth and reliable data exchange. For precise control and stability, the system uses an MPU 9250 IC, which provides the necessary data for PID. This sensor is crucial for maintaining accurate and responsive servo movements.

The prototype accurately replicates the mechanics of the actual bot. Instead of using BLDC motors, which are common in final implementations, the prototype uses servos for simplicity and ease of testing. Control of the system is achieved through a mobile app, which communicates with the ESP-32 via WiFi or Bluetooth. This setup allows for flexible and remote control of the prototype, making it a robust platform for testing and development before scaling to more complex systems with BLDC motors.

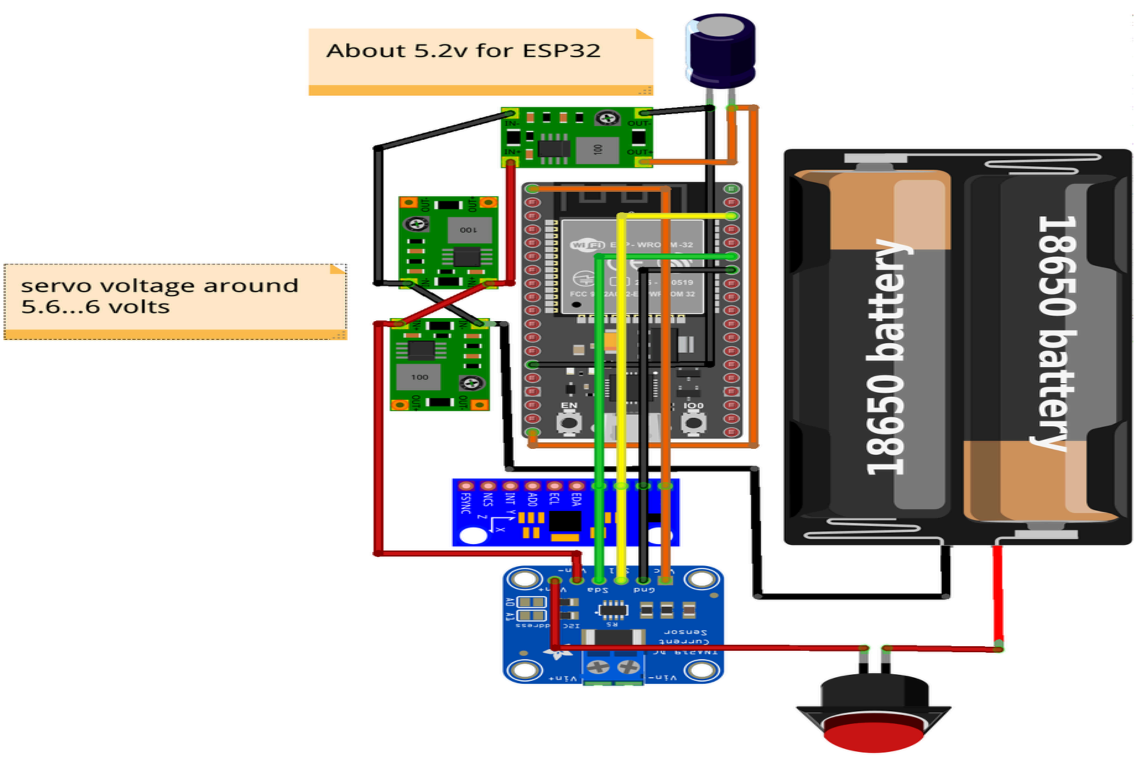


Fig. Circuitry for prototype model

5. Application of the proposed robot in a societal context:

Dharma- our autonomous battlefield-compatible quadruped robot- recognizes targets in combat zones, navigates autonomously, and provides real-time video feeds, improving military operations. Using lidar, thermal imaging, and two cameras- one for target detection and another for unknown terrain traversing and mapping, detects potential hazards and gives output as a video feed to the base station. Machine learning enables predictive maintenance and adaptive learning from new environments, enhancing operational efficiency. Its smartwatch interface enables health tracking, remote control, and GPS monitoring. With its autonomous walking, following, and shooting capabilities, the robot provides soldiers with enhanced safety and tactical assistance. The most striking feature of our Dharma is its capability to detect enemies or lock targets through its image processing capability. The amalgamation of sophisticated robots and intelligent technology facilitates reconnaissance, monitoring, and interaction, guaranteeing optimal mission results while mitigating human hazards.

6. Size of Robot Proposed for Proof of Concept (Small Version):

a) Length in cm: 20

b) Width in cm: 15

c) Height in cm: 12

7. Size of Robot proposed as prototype (Actual Version):

a) Length in cm: 80

b) Width in cm: 60

c) Height in cm: 40

8. Timeline for Robot Making with Milestones. (Divided into activities Vs. number. of days)

Stage 2: Proof of Concept Stage (90 Days/ 3 Months)

Objective: Develop and submit a small functional prototype with all peripherals within 3 months.

Activities and Milestones:

- Days 1-20: Planning and Procurement
  - Milestone: Create a detailed project plan and order required components, manufacture all 3D printable parts.
- Days 21-60: Initial Prototype Development
  - Milestone: Assemble and test the initial prototype.
- Days 61-80: Prototype Refinement
  - Milestone: Refine and optimize the prototype based on testing results.
- Days 81-90: Final Testing and Submission Preparation
  - Milestone: Complete final testing and prepare for submission.

Stage 3: Submission of Robot Prototype (90 days/ 3 months)

Objective: Build and submit a fully functional robot prototype within 3 months.

Activities and Milestones:

- Days 1-20: Detailed Planning and Enhanced Design
  - Milestone: Develop detailed plans and an enhanced design for the full prototype, order all necessary parts, and manufacture all 3D printable parts.
- Days 21-70: Comprehensive Assembly
  - Milestone: Complete the assembly of the full robot while printing more parts for testing and integration.

- Days 71-85: Integration of Systems

  - Milestone: Integrate all previously built peripheral systems along with freshly developed mechanical, electronic, and software components into the final prototype.

- Days 86-90: Final Testing and Submission Preparation

  - Milestone: Conduct extensive testing and prepare the robot for submission

Stage 4: Installation and Commissioning of Robot (40 days)

Objective: Provide detailed component information and commission the robot with full functionality.

Activities and Milestones:

- Days 1-10: Documentation of Components

  - Milestone: Complete documentation of all components and their manufacturer detail.

- Days 11-25: Staff Training Preparation

  - Milestone: Develop training materials and schedule.

- Days 26-35: Demonstration and Staff Training

  - Milestone: Conduct demonstrations and training sessions for gallery staff.

- Days 35-40: Installation and Commissioning

  - Milestone: Complete the installation and commissioning of the robot with all accessories.

9. Please attach the proposed outline (photography) for the understanding of the evaluation committee.