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DEVELOPMENT OF WHEELED ROBOT FOR SURVILLENACE APPLICATIONS

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Abstract: Artificial intelligence (AI) had a significant impact on daily life as the technology has advanced. As a result of this embrace, robot interaction has become common place. Robots have become an increasing number of conventional in lots of real-international eventualities. Housekeeping, scientific aid, human help are some not unusual place implementations of robots. Military and Security are also number one area in which robotics is being researched and implemented. Robots with the reason of surveillance in struggle zones and terrorist situations need specific functionalities to perform their responsibilities with precision and performance. The Military Surveillance Robot superior using Robot Operating System. This work focuses on kinematics study of wheeled robot for surveillance applications. The kinematics of surveillance robot categorised into two types: forward and inverse. The forward kinematics of a wheeled robot. It is an all-around robot. Denavit-Hartenberg parameterization is used to calculate the entire kinematics of the wheel and the base. Our method varies from the standard method, which derives the Jacobian of the wheel and base directly from velocity transformations and restrictions. Kinematic analysis is based on the placement of coordinate axes inside the robot and its surroundings, with matrices to define transformations between coordinate systems.

Keywords*:* Arduino Uno, Surveillance, Robot, Raspberry Pi, Pi Camera, GPS.

INTRODUCTION

Robotics has come a long way to advances in mechatronics and mathematical modelling. Machines capable of jumping from high-rise buildings, detecting landmines in the ground, executing operations, and troubleshooting have evolved from an iron piece that could move only a few inches. The system's core component is Arduino, a microcontroller that handles all of the system's functions. We can utilise this type of technology on the border to keep track of all of our adversary's activities. This robot has camera and mechanical abilities. IR sensors, arm Which are useful for both spying and military purposes in general. Spying and surveillance are critical tasks; we cannot risk putting someone's life at risk. Instead, we can utilise robots who do not require sleep, do not feel hungry, do not have emotions, and just carry out their responsibilities and follow orders. Nothing is more valuable than human life. The use of such robots in border areas could save many lives. We can also put these personnel to other uses. To control the robot, we use an Android app. This software uses Wi-Fi or Bluetooth to connect to the microcontroller. Because the robot's base is made up of wheels, it can navigate on both rough and wet surfaces [1].

LAW OF ROBOTICS

The Three Laws of Robotics were created by popular science fiction writer Isaac Asimov. A robot shall not damage a human being or allow a human being to be harmed by its actions. Except where it conflicts with the first law, a robot must always accept human commands. Except if the first law conflicts with the first or second law, a robot must safeguard its own existence [2].

Law 1:

A robot may not injure a human being, or, through inaction, allow a human to be harmed.

Law 2:

A robot must obey orders given by humans except when they conflict with the first law.

Law 3:

A robot must protect its own existence unless that conflicts with the first or second

LITERATURE SURVEY

MILITARY SURVILLENANCE

The military robots used in the defence environment for attack operations and surveillance are controlled via standard short-range RF waves, which limits their capability, reliability, and operation functions in terms of long-distance remote control. To address this issue, the author developed an embedded self-neural schema-based architecture for autonomous control and decision making, as well as a reporting system. It includes a multi–angled rotatable camera for a better view of the military installation or other locations. For motor control, an ultrasonic sensor is employed for direction control and object detection. The intrude area surveillance robot system is used for real-time surveillance [2].

Fig. 1. Military surveillance robot [2]

ROBOTS IN MILITARY

Let us recollect some practical robots in defence now that we have a basic understanding of battle field robots. One of the most important characteristics of military robots is that they are not fully automated. Humans are in fact controlling them from afar. Robots, also known as unmanned machines, can be any moving item or a flying aeroplane equipped with the necessary sensors, LIDARS (Laser-based Communication RADARS), cameras, and other equipment. Their missions can range from bomb disposal to assessing hostile territory.

Types of military surveillance

- Unmanned aerial vehicle
- Unmanned ground vehicle
- Unmanned surface vehicle
- Remotely operated vehicle
- Autonomous underwater vehicle

UNMANNED AERIAL VEHICLE

A drone, or unmanned aerial vehicle, is an aircraft that does not have a human pilot, crew, or passengers on board. A UAV is part of an unmanned aerial vehicle, which also includes a ground-based controller and a communications system with the UAV [3].

Fig. 2. Unmanned aerial vehicle [3]

The adoption of UAVs by government defence projects as well as civil use applications is fast expanding, increasing demand for UAVs.

UNMANNED GROUND VEHICLE

An unmanned ground vehicle (UGV) is a vehicle that works without the presence of a human onboard when in touch with the ground. UGVs can be employed in a variety of situations where having a human operator present is inconvenient, risky, or impossible. In general, the vehicle will have a collection of sensors to monitor its surroundings and will either make decisions on its own or relay the information to a human operator at a remote location who would manage the car via teleoperation [4].

Fig. 3. Unmanned ground vehicle [4]

UNMANNED SURFACE VEHICLE

USVs (unmanned surface vessels) are also known as autonomous surface craft (ASC). They remove the operators from the platform and allow different modes of operation, as the name implies. Unmanned surface vehicles have gotten more capable as global positioning systems have become more compact, effective, and economical. The rapid rise of USVs for many applications has also been aided by the availability of affordable, long-range, and higher-bandwidth wireless communications systems. Academic labs, companies, and government users have all produced and proven USVs today [5].

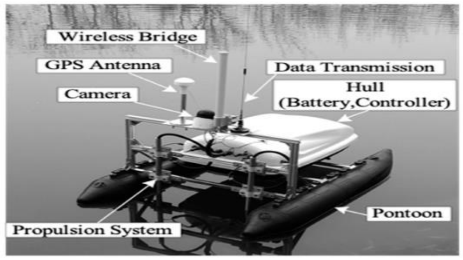

Fig. 4. Unmanned surface vehicle [5]

REMOTELY OPERATED UNDERWATER VEHICLE

ROVs, or remotely operated underwater vehicles, are underwater robots utilised in science, entertainment, the military, and the offshore oil industry. Their primary purpose is to interact with the underwater environment in various ways. It's a sophisticated system that's only found in developing and poor countries around the planet. Countries with numerous water bodies and a history of maritime events Rescue efforts can benefit greatly from ROVs. We developed a ROV and outfitted it with a surveillance system for this research project. Our ROV will assist rescuers by monitoring the underwater environment and transmitting footage [6].

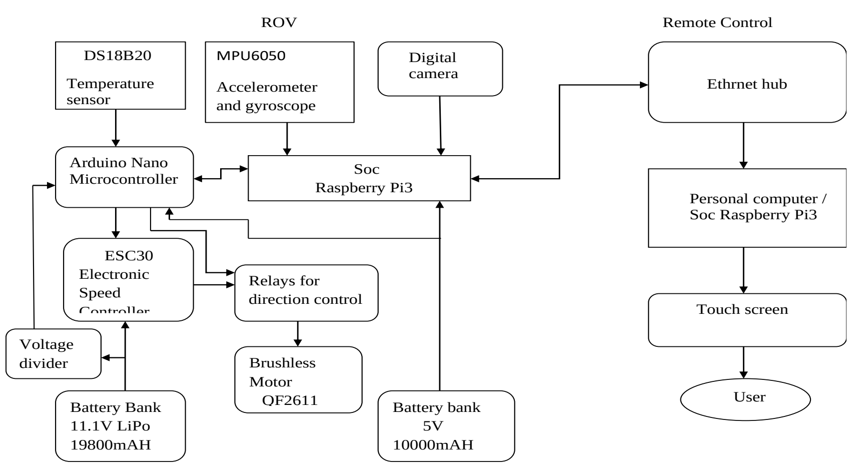

Fig. 5. Block diagram of Remote operated underwater vehicle [6]

AUTONOMOUS UNDERWATER VEHICLE

Exploration and inspection of the oceans are currently a major challenge for the industry. Due to current technologies or the development of new ones, underwater instrumentation and measurements are improving to meet the demands of the new offshore industry. Subaquatic tasks are carried out by autonomous underwater vehicles, a subcategory of submarine. This vehicle has benefits for underwater operations, such as safety and reliability inspections, but it also has drawbacks, such as sensor systems, monitoring and communications systems, autonomous operational endurances, propulsion systems, and mapping designs, among others [7].

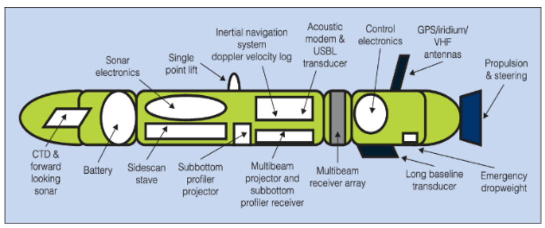

Fig. 6. Autonomous Underwater Vehicles [7]

WHEELED ROBOT

Although all robots are capable of mobility by definition, the term "mobile robots" refers to robots that can move away from their base using some sort of locomotion system. The most common example is a set of wheels. Mobile robots have a significant advantage over fixed-base manipulators in terms of workspace. As a result, such robots are critical in-service applications that require higher autonomous motion capabilities. Any wheeled vehicle is subject to kinematic restrictions that limit its local mobility while preserving the ability to attain arbitrary configurations with the right manoeuvres. The controlling of the wheeled mobile robots extremely difficult, and research into these systems has sparked some recent advances in nonlinear control [8].

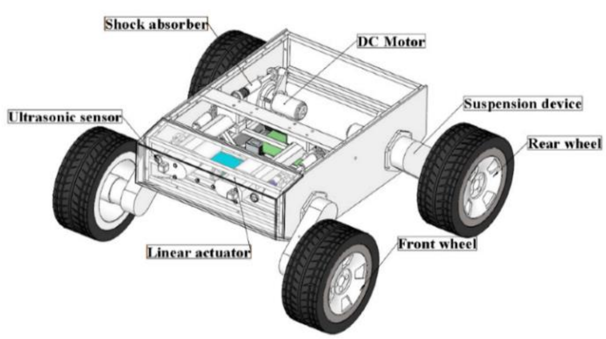

Fig. 7. Wheeled robot [8]

TYPES OF WHEELED ROBOT

There are different kinds of wheels to choose from, for a Wheeled Mobile Robot (WMR)

- Two wheels
- Three wheels
- Four wheels

WORKING OF WHEELED ROBOT

Wheeled robots are self-propelled robots that navigate the ground using powered wheels. This design is simpler than treads or legs, and it is easier to design, manufacture, and programme for movement in flat, non-rugged terrain by using wheels. They can also be controlled better than other robots. Wheeled robots have the disadvantage of being unable to travel well over obstacles such as rocky ground, steep drops, or locations with little friction. Consumers choose wheeled robots because of their inexpensive cost and ease of use, as well as their differential steering. Robots can have any number of wheels, however for static and dynamic equilibrium, three wheels are sufficient. Additional wheels can help with balance, but when the terrain isn't flat, additional mechanisms will be necessary to maintain all of the wheels on the ground [8].

COMPONENTS OF WHEELED ROBOT

There are main components of wheeled robot like

- Motor Controllers.
- Network.
- Programmable Controllers.
- Remote Control (RC)
- Sensors.
- Servo Controllers.
- USB Devices.
- Voltage Regulators.

MOTOR CONTROLLERS

A Motor Controller is a device that connects the microcontroller, batteries, and motors in your robot. Because a microcontroller can only produce about 0.1 amps of current, and most actuators require more, a motor controller is required [9].

Fig. 8. Motor controller [9]

REMOTE CONTROL (RC)

A remote control (RC) is a small electronic device that can be used to control another device, such as a television, radio, or audio/video recording device. Infrared signals are most typically used; however, radio frequency signals are also used. Volume, channel, track number, and other functions can all be controlled with the remote control. Modern remote-control devices frequently feature more control functions than the gadget itself, which may just have a few key important controls. Clicker, flipper, tuner, changer, or converter is another name for a remote control [9].

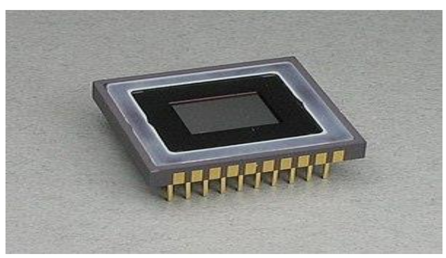

Fig. 11. Remote Control [9]

SERVO CONTROLLERS

A servo motor is a rotary actuator that can control angular position, velocity, and acceleration precisely. It is made comprised of an appropriate motor and a position feedback sensor. A servo is a precise and powerful technique of turning rotational motion into linear motion at its most basic level. A servo (also known as a servo motor) is made up of the following components: An AC or DC electric motor, a controller board, and a potentiometer make up the Electronic Assembly [9].

Fig. 12. Servo Controller [9]

USB DEVICES

These are USB gadgets that use your PC's USB port to control your robot or other I/O. External hard drives and flash drives are common USB devices, but USB is used by a wide range of goods, making it the most extensively used computer interface [9].

Fig. 13. USB Devices [9]

VOLTAGE REGULATOR

Any electrical or electronic device that keeps the voltage of a power source within acceptable limits is known as a voltage regulator. The voltage regulator is required to keep voltages within the acceptable range for electrical equipment that uses that voltage. This device is commonly employed in all sorts of motor vehicles to adjust the generator's output voltage to the electrical load and the battery's charging requirements. Voltage regulators are also employed in electronic devices where excessive voltage changes might be harmful. Voltage regulators in automobiles use a spring-loaded, double-pole switch to quickly switch between one of three circuit states [9].

Fig. 14. Voltage Regulator [9]

LEGGED ROBOT

Border security forces continue to be the primary source of surveillance in risky areas. Some technologies, such as unmanned aerial vehicles (UAVs) and tracked-wheeled robots, are unreliable and incapable of performing duties. A four-legged walking robot can tackle this problem while also lowering the chance of human death. If the path is bumpy, slick, or full of obstacles, the legged Mechanism balances the stresses on the body. Support polygons, optimal foothold selection, and recuperation techniques, to name a few, are all used in 4-legged walking robots. Many critical aspects for a walking robot are also understood, but extensive research is still underway. Leg robots are a form of mobile robot that moves by using movable limbs, such as leg mechanisms. They are more adaptable than wheeled robots and can traverse a wide range of terrains, but these benefits come at the expense of higher complexity and power consumption [10].

Fig. 15. Legged Robot [10]

WORKING OF LEGGED ROBOT

A series of point interactions between the robot and the ground characterises legged robot mobility. Adaptability and manoeuvrability in tough terrain are two significant advantages. Because only a few point interactions are necessary, the quality of the ground between them is unimportant as long as the robot maintains sufficient ground clearance. Furthermore, a walking robot can traverse a pit or chasm if its reach is greater than the breadth of the hole. The ability to control items in the surroundings with considerable skill is another advantage of legged locomotion. The dung beetle is a wonderful insect example because it can roll a ball while locomoting with its dexterous front legs. Power and mechanical complexity are two major drawbacks of legged mobility [10].

TYPES OF LEGGED ROBOT

They can be classified according to the number of limbs they employ, which determines the gaits they can do. Many-legged robots are more stable, while robots with fewer legs are more manoeuvrable.

- One-legged robot (pogo stick robots)
- Two-legged robot (Bipedal robots)

- Three-legged robot (Tripodal robot)
- Four-legged robots (Quadrupedal robots)
- Six-legged robots (hexapods)
- Eight-legged robots

WORKING OF LEGGED MOBILE ROBOT

A series of point interactions between the robot and the ground characterises legged robot mobility. Adaptability and manoeuvrability in tough terrain are two significant advantages. Because only few point interactions are necessary, the quality of the ground between them is unimportant as long as the robot maintains sufficient ground clearance. Furthermore, a walking robot can traverse a pit or chasm if its reach is greater than the breadth of the hole. The ability to control items in the surroundings with considerable skill is another advantage of legged locomotion. The dung beetle is wonderful insect example because it can roll ball while locomoting with its dexterous front legs [10].

APPLICATIONS OF LEGGED ROBOT

Our goal is to create a mobile platform that can handle a wide range of real-world tasks. We demonstrated that the legged robot could do industrial inspection and be deployed as a payload delivery system for search and rescue during the ERL and ARGOS challenges. While the majority of robotic solutions are tailored to a single task, we demonstrate that ANY mal can accomplish several tasks. Inspection of Industry With the payload depicted in Fig. 2, the robot may undertake optical, thermal, and auditory inspections. While a thorough explanation of all tools is beyond the scope of this paper, we would like to highlight the specific strategy and outcomes for pressure gauge examination at the ARGOS challenge. Inspection targets were identified as checkpoints in the mission description during the competition. To reliably point the camera at a checkpoint, the robot first travels to a pre-calculated optimal posture at the inspection point, then derives the appropriate pan-tilt angles online based on the robot's position and the checkpoint, before switching to tracking mode.

KIMEMATIC OF WHEELED ROBOT

Kinematics is the study of motion's geometry. WMRs are interested in determining the robot's motion based on the geometry of the limitations imposed by the movement of the wheels. The assignment of coordinate axes inside the robot and its surroundings, as well as the use of (4x4) matrices to define transformations across coordinate systems, are the foundations of our kinematic analysis. Each step is meticulously outlined to provide a solid foundation for WMR dynamic modelling and feedback control. After that, dynamic models can be used to create dynamics-based controllers and simulators. A kinematic methodology can also be used to build WMRs that meet mobility requirements like the DOF. The development of kinematics for stationary manipulators parallels our kinematic analysis of WMRs. The Denavit-Hattenberg convention[l8] is used to provide coordinate axes to each of the robot joints in a typical approach for x+ nodeling the kinematics of stationary robotic manipulators. On the robot, (4x4) homogeneous transformation A-matrices connect successive coordinate systems. Between subsequent coordinate systems, the A-matrices are totally defined by four distinctive parameters (two displacements and two rotations). Each A-matrix represents the geometry and size of a robot link, as well as the corresponding joint's translation (for prismatic joints) or rotation (for rotational joints). The steering links and wheels of a WMR are given coordinate axes, and transformation matrices are defined using the Sheth-Uicker convention [11].

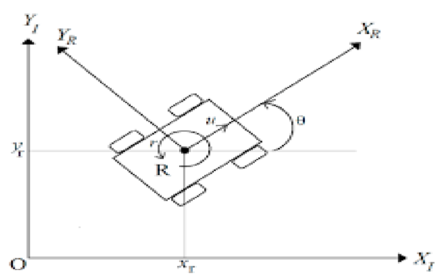

Fig. 16. wheeled robot [11]

KINEMATIC CONFIGURATIONS

Kinematic configuration of a robot with four omnidirectional wheels [11].

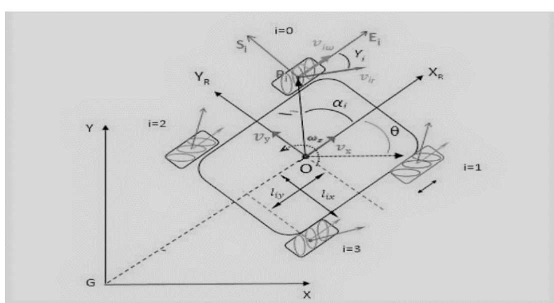

Fig. 17. Kinematic Configuration parameters [11]

The configuration parameters and system velocities are defined as follows:

x, y, θ, robot's position (x, y) and its orientation angle θ (The angle between X and XR);

X G Y, inertial frame; x, y are the coordinates of the reference point O in the inertial basis;

$XROYR$, robot's base frame; Cartesian coordinate system associated with the movement of the body centre;

$SiPiEi$, coordinate system of i'th wheel in the wheel's centre point Pi O, Pi, the inertial basis of the Robot in Robot's frame and $Pi = \{XPi, YPi\}$ the centre of the rotation axis of the wheel i ;

OP, is a vector that indicates the distance between Robot's centre and the centre of the wheel ith;

lix, liy, lix, half of the distance between front wheels and liy half of the distance between front wheel and the rear wheels.

li, distance between wheels and the base (centre of the robot O);

ri, denotes the radius of the wheel i (Distance of the wheel's centre to the roller centre)

r, denotes the radius of the rollers on the wheels.

αi, the angle between OPi and XR, βi, the angle between S i and XR;

γi, the angle between vir and Ei;

ωi [rad/s], wheels angular velocity;

$vi\omega$ [m/s], $i = 0,1,2,3 \in R$, is the velocity vector corresponding to wheel revolutions

vir, the velocity of the passive roller in the wheel i;

[wsi wEi ωi] T, Generalized velocity of point Pi in the frame $SiPiEi$;

[vSi vEi ωi] T, Generalized velocity of point Pi in the frame $XROYR$;

vx, vy [m/s] - Robot linear velocity;

ωz [rad/s] - Robot angular velocity.

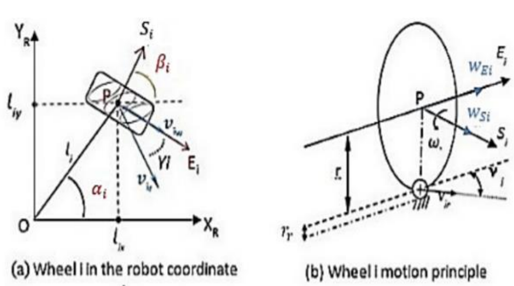

Fig. 18. Wheeled robot coordinate system [11]

REPRESENTING ROBOT POSITION

To specify the robot's position on the plane, we build a relationship between the plane's global reference frame and the robot's local reference frame, as shown in equation (1.1). The axes X1 and Y1 define an arbitrary inertial basis on the plane as the global reference frame, starting at some point O: X1, Y1. Choose a point P on the robot chassis as its position reference point to determine the robot's position. The robot's local reference frame is defined by the basis XR, YR, which defines two axes relative to P on the robot chassis. The coordinates x and y specify P's position in the global reference frame, and the angular difference between the global and local reference frames is given by These three elements can be used to define the robot's pose as a vector. The subscript I is used to clarify the basis of this pose as the global reference frame [12].

$$\boldsymbol{\xi_1} = \begin{bmatrix} \mathbf{x} \\ \mathbf{y} \\ \boldsymbol{\theta} \end{bmatrix} \tag{1}$$

It will be necessary to translate motion along the axes of the global reference frame to motion along the axes of the robot's local reference frame in order to characterise robot motion in terms of component movements. Of course, the mapping is determined by the robot's current position. The orthogonal rotation matrix is used to accomplish this transfer.

$$\mathrm{R}_\theta = \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

This matrix can be used to map motion in the global reference frame {X1, Y1} to motion in terms of the local reference frame {XR, YR}. This operation is denoted by $(\theta)\xi_1$ because the computation of this operation depends on the value of θ.

$$\dot{\xi}_\mathrm{R} = \mathrm{R}\left(\frac{\pi}{2}\right)\dot{\xi}_\mathrm{I} \tag{3}$$

For example, consider the robot in equation (2). For this robot, because $\theta = \frac{\pi}{2}$ we can easily compute the instantaneous rotation matrix R:

$$R\left(\frac{\pi}{2}\right) = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{4}$$

Given some velocity (x, y, θ) in the global reference frame we can compute the components of motion along this robot's local axes XR and YR. In this case, due to the specific angle of the robot, motion along XR is equal to y and motion along YR is -x [12].

$$\xi_R = R\left(\frac{\pi}{2}\right)\xi_1 = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} x \\ y \\ \theta \end{bmatrix} = \begin{bmatrix} x \\ -y \\ \theta \end{bmatrix} \tag{5}$$

FORWARD KINEMATIC MODEL

In the simplest cases, the mapping described in equation (3) is sufficient to generate a formula that captures the forward kinematics of the mobile robot: how does the robot move, given its geometry and the speeds of its wheels. This differential drive robot has two wheels, each with diameter r. Given a point P centred between the two drive wheels, each wheel is a distance l from P. Given r, l, θ and the spinning speed of each wheel, φ_1 and φ_2 and, a forward kinematic model would predict the robot's overall speed in the global reference frame [12]:

$$\xi_I = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix} = f(l, r, \varphi_1, \varphi_2) \tag{6}$$

From equation (3) we know that we can compute the robot's motion in the global reference frame from motion in its local reference frame: $\xi_1 = R(\theta)^{-1}\xi_R$. Therefore, the strategy will be to first compute the contribution of each of the two wheels in the local reference frame, ξ_R. For this example of a differential-drive chassis, this problem is particularly straightforward. Suppose that the robot's local reference frame is aligned such that the robot moves forward along +XR as in equation (1). First consider the contribution of each wheel's spinning speed to the translation speed at P in the direction of +XR. If one-wheel spins while the other wheel contributes nothing and is stationary, since P is halfway between the two wheels, it will move instantaneously with half the speed: $x_{r1}=\frac{1}{2}r\varphi_1$ and $x_{r2}=\frac{1}{2}r\varphi_2$ .In a differential drive robot, these two contributions can simply be added to calculate the component of ξ_R . Consider, for example, a differential robot in which each wheel spins with equal speed but in opposite directions. The result is a stationary, spinning robot. As expected, xRwill be 0 in this case. The value of y_R is even simpler to calculate. Neither wheel can contribute to sideways motion in the robot's reference frame, and so y_R is always 0. Finally, we must compute the rotational component θ_R of ξ_R. Once again, the contributions of each wheel can be computed independently and just added. Consider the right wheel (we will call this wheel 1). Forward spin of this wheel results in counter-clockwise rotation at point P. Recall that if wheel 1 spins alone, the robot pivots around wheel 2. The rotation velocity ω_1 at P can be computed because the wheel is instantaneously moving along the arc of a circle of radius 2l: $\omega_1 = \frac{r\varphi_1}{2l}$

The same calculation applies to the left wheel, with the exception that forward spin results in clockwise rotation at point p;

$$\omega_2 = \frac{-r\varphi_2}{2l} \tag{7}$$

Combining these individual formulae yields a kinematic model for the differential-drive example robot.

$$\dot{\xi}_1 = R(\theta)^{-1}\begin{bmatrix} 0 \\ \frac{r\dot{\varphi}_1}{2} + \frac{+\dot{\varphi}_2}{2} \\ 0 \\ \frac{r\dot{\varphi}_1}{2l} + \frac{-r\dot{\varphi}_1}{2l} \end{bmatrix} \tag{8}$$

We can now use this kinematic model in an example. However, we must first compute $R(\theta)^{-1}$.In general, calculating the inverse of a matrix may be challenging. In this case, however, it is easy because it is simply a transform from ξ_R to ξ_1 rather than vice-versa:

$$R(\theta)^{-1} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

(9)

Suppose that the robot is positioned such that $= \frac{\pi}{2}$, and r=1 and l=1. If the robot engages its wheels unevenly, with speeds $\varphi_1 = 4$ and $\varphi_2 = 2$, we can compute its velocity in the global reference frame:

$$\dot{\xi}_1 = \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 3 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 3 \\ 1 \end{bmatrix}$$

(10)

so, this robot will move instantaneously along the y axis of the global reference frame with speed 3 while rotating with speed 1. This approach to kinematic modelling can provide information about the motion of a robot given its component wheel speeds in straightforward cases [12].

INVERSE KINEMATIC MODELS

The technical implementations of wheeled robots are constantly attracting development. For industries, transportation, and specific tasks, these systems are frequently employed. The ability to move through the environment in order to execute navigation and tasks is one of the most important needs for an autonomous mobile robot. The agility and manoeuvrability of wheeled robots should be excellent [12].

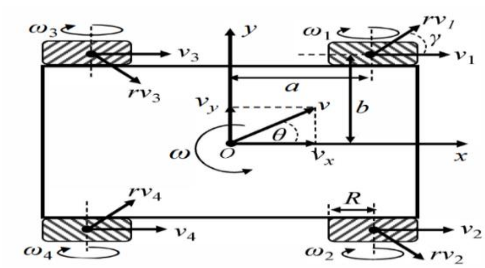

Fig. 19. Vector and coordinate system of 4-wheel robot [12]

Inverse kinematic model of the mobile robot is derived from the movement vector of four-wheel drive mobile robot platform. Vector of the robot velocity v which has parallel direction to the x coordinate of Vx and Vy vector components are derived by [12].

$$\mathbf{V}_x = v\cos \mathbf{e} \tag{1}$$

$$\mathbf{v}_{\mathrm{x}} = v\sin \mathrm{e} \tag{2}$$

where e is the lateral direction angle of robot movement velocity. Angular velocity of the robot is defined by w at the centre point of the mobile robot that indicates left or right turning movement. Robot dimension is denoted by radius of a and b between body centre robot and wheel axis of ai: {a, a, -a, -a} and bi: {b, -b, b, -b} where i: {1, 2, 3, 4} which represented wheel numbers. Linear velocity vector of the wheel and velocity of mecanum roller direction each wheel is indicated by Vi and rv_i, respectively. Tilted angle y between v and r_v is 45° which represents the mecanum roller angle each wheel of Y_i: {7[/4, - 7[/4, - 7[/4, 7[/4}. The velocity vector equation of the mobile robot toward coordinate system component can be calculated by

$$v_i + rv_i\cos(y_i) = v_x - b_{iw} \tag{3}$$

$$rv_i\sin(y_i) = v_y + a_{iw} \tag{4}$$

Substitution between (3) and (4) using tan (Y_i), the linear velocity each wheel can be obtained:

$$v_i = v_x - b_i\omega - \frac{v_y + a_i\omega}{tan(\gamma_i)} \tag{5}$$

Since tan (Y_i) are denotated in (5) by tan (Yi: {1, -1, -1, 1}, the linear velocity of the mecanum wheel is:

$$v_1 = v_x - v_y - a_w - b_w \tag{6}$$

$$v_2 = v_x + v_y + a_w + b_w$$

(7)

$$\mathbf{v}_3 = \mathbf{v}_\mathrm{x} + \mathbf{v}_\mathrm{y} - \mathbf{a}_\mathrm{w} - \mathbf{b}_\mathrm{w}$$

(8)

$$\mathbf{v}_4 = \mathbf{v}_\mathrm{x} - \mathbf{v}_\mathrm{y} + \mathbf{a}_\mathrm{w} + \mathbf{b}_\mathrm{w}$$

(9)

While the angular wheel velocities are vi=ωR and R is the radius of four mecanum wheels. Eq. (6)-(9) is modified

$$\begin{bmatrix}\omega_1\\ \omega_2\\ \omega_3\\ \omega_4\end{bmatrix} = \frac{1}{R}\left[\begin{bmatrix}1 & -1 & -(a+b)\\ 1 & 1 & (a+b)\\ 1 & 1 & -(a+b)\\ 1 & -1 & (a+b)\end{bmatrix}\right]\begin{bmatrix}v_x\\ v_y\\ \omega\end{bmatrix}$$

(10)

shows mathematical model of the inverse kinematic to be implemented to obtain angular velocities each mecanum wheels by input of vector component of Vx, Vy and w according to the lateral direction angle e without changes the robot facing in certain direction. Angular speed of the stepper motor theoretically can be calculated by:

$$\omega_{FS} = \frac{1.8}{360} 60f$$

(11)

$$\omega_{\mathrm{Hs}}(\mathrm{RPM}) = \frac{\omega_{\mathrm{FS}}}{2}$$

(12)

COMPONENTS OF SURVILIENANCE ROBOT

MOTOR DRIVER

The L298 is a 15-lead Multiwatt and PowerSO20 integrated monolithic circuit. It's a high voltage, high current twin full-bridge driver that can receive conventional TTL logic levels and drive inductive loads including relays, solenoids, DC and stepping motors. There are two enable inputs to enable or disable the device independently of the input signals. The emitters of each bridge's bottom transistors are linked together, and the matching external terminal may be used to connect an external sensing resistor. A second supply input is supplied so that the logic may operate at a lower voltage [22].

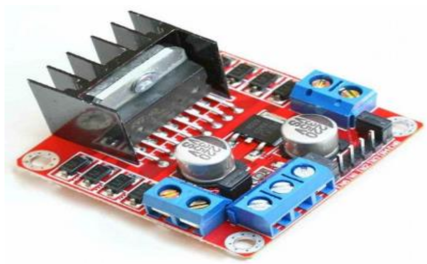

Fig 20: motor driver [22]

DC MOTORS

A DC motor in simple words is a device that converts direct current (Electrical energy) into mechanical energy. The very basic construction of a dc motor contains a current carrying armature which is connected to the supply end through Commutator segments and brushes and placed within the north south poles of a permanent or an electro-magnet [22].

Fig 21: DC motors [22]

JUMPER CORD

Jump cord is an electrical cord, or institution of them in a cable, with a connector or pin at each give up, it is usually used to interconnect the components of a breadboard or different prototype or take a look at circuit, internally or with different device or additives, without soldering. Individual bounce wires are ready thru way of technique of placing their "surrender connectors" into the slots supplied in a breadboard, the header connector of a circuit board, or a bit of take a look at device [22].

Materia: Tin plated soft Copper wire

- Conductor: 0.54mΩ/cm
- Resistance: 0.54mΩ/cm
- Conductivity: Min. 96%
- Current Rating: 6 Amps at 70°C for 0.50mm
    - 7 Amps at 70°C for 0.56mm
    - 8.5 Amps at 70°C for 0.70mm
    - 7.5 Amps at 70°C for 0.60mm
    - 10 Amps at 70°C for 0.80mm

Fig 22: Jumper wire [22]

ARDUINO

Arduino is an open-supply hardware and software program company, project, and consumer network that designs and manufactures single-board microcontrollers and microcontroller kits for constructing virtual devices. Arduino forums are to be had commercially from the reputable internet site or thru legal distributors. Arduino board designs use a whole lot of microprocessors and controllers. The forums are prepared with units of virtual and analog input/output (I/O) pins that can be inter-confronted to diverse growth forums ('shields') or breadboards (for prototyping) and different circuits. The forums function serial communications interfaces, together with Universal Serial Bus (USB) on a few models, that are extensively utilized for loading programs. The microcontrollers may be programmed the use of the C and C++ programming languages, the use of a trendy API which is likewise referred to as the Arduino language, stimulated with the aid of using the Processing language and used with a changed model of the Processing IDE [22].

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V

- Input Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA
- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

Fig 23: Arduino UNO [22]

SERVO MOTOR

A servo motor is a type of motor that can rotate with pinpoint accuracy. This type of motor often includes a control circuit that offers feedback on the present position of the motor shaft; this feedback allows servo motors to rotate with remarkable accuracy. A servo motor is used when you wish to spin an object at a specified angle or distance. It is just a motor that is controlled by a servo system. If the motor is powered by a DC power source, it is referred to as a DC servo motor; if it is driven by an AC power supply, it is referred to as an AC servo motor [22].

Fig 24: servo motor [22]

RESISTOR

A passive electric issue with terminals which are used for both proscribing or regulating the float of electrical cutting-edge in electric circuits. The major cause of resistor is to lessen the cutting-edge float and to decrease the voltage in any specific part of the circuit. It is product of copper wires that's coiled round a ceramic rod and the outer a part of the resistor is covered with an insulating paint [22].

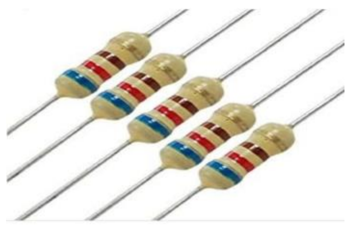

Fig 25: resistors [22]

ARDUINO CABLE

This cable is used to connect any Arduino board to your computer; you may also connect your USB printer, scanner, and other devices to your computer. The USB cable features a USB type A connection on one end and a USB type B connector on the other. The USB type-A connector is connected to the power supply or the programming device (e.g., your computer/laptop), while the USB type-B connector is connected to the Arduino UNO or MEGA 2560 board. Arduino USB Cables such as mini, USB A/B, and Mini B are suitable for Arduino UNO, Mega, and other Arduino boards. This cable is used to connect any Arduino board to your computer; you may also connect your USB printer, scanner, and other devices to your computer. These cables transmit data at high rates with error-free, high-overall performance transmission. You can select any of the cables based on which devices must be connected [22].

- USB Type: Type-A to Type-B
- Weight: 25 gm.
- Length: 50 cm.

- Fully compatible with the PC.
- Aluminium under-mould shield helps meet FCC requirements on KMI/RFI interference.

Fig 26: Arduino cable [22]

POWER SUPPLY

A DC power supply is one that provides a fixed polarity voltage (either positive or negative) to its load. A DC power supply may be powered by a DC source or an AC source, such as the power mains, depending on its design. Some DC power supply are powered by mains electricity. A transformer is sometimes used in such power supply to convert the input voltage to a greater or lower AC voltage. The filter eliminates the majority of the AC voltage changes, but not all of them; the residual voltage variations are referred to as ripple. The quantity of filtering required by a power supply is determined by the electric load's tolerance of ripple. High ripple is permitted in some applications; therefore no filtering is necessary. In some battery charging applications, for example, a mains-powered DC power source can be implemented with nothing more than a switch [22].

WIRELESS CAMERA

Wireless security cameras are less difficult to install than cable security cameras. Many connected cameras link to your home's electrical infrastructure, thus installation will require the services of a professional. Wi-Fi or other networks are used by wireless cameras. Most cameras may be set up and connected in less than 15 minutes if you follow the instructions. Wireless security cameras are frequently preferable for renters, those new to home security, or those on a tight budget. Wireless security cameras are not only less expensive than wired systems, but they are also easier to handle and carry. Simply disconnect them and you're good to go [22].

Fig 27: Wireless cameras [22]

BUCK CONVERTER

In SMPS circuits, the Buck Converter is utilised when the DC output voltage must be lower than the DC input voltage. Any DC source or rectified AC can be used as the DC input. When electrical isolation between the switching circuit and the output is not required, but the input is from a rectified AC source, a mains isolating transformer can provide isolation between the AC source and the rectifier. The Buck Converter's switching transistor between the input and output is constantly on and off at a high frequency. In order to ensure a consistent output, the During the on periods of the switching transistor, the energy stored in the inductor L is used to keep the load supplied during the off periods. The circuit's functionality is contingent on what is occasionally available. A Flywheel Circuit is another name for it. This is because the circuit functions similarly to a mechanical flywheel. fed frequent energy pulses, maintains spinning smoothly (outputting energy) at a constant rate [22].

Fig 28: Buck Converter [22]

BATTERY

A lithium polymer battery, or more precisely a lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, and others), is a pouch-style rechargeable lithium-ion battery. LiPo batteries, unlike cylindrical and prismatic cells, are packaged in a soft pouch, which makes them lighter but also less rigid. Users of batteries have been perplexed by the term "lithium polymer." It might be construed in two different ways. The term "lithium polymer" originally referred to an emerging technology that used a polymer electrolyte rather than the more typical liquid electrolyte. The result is a "plastic" cell that could theoretically be thin, flexible, and made in a variety of forms while avoiding electrolyte leakage. This technology is still in the early stages of development and commercialization, and research is ongoing. The second connotation emerged when certain manufacturers began using the term "polymer" to refer to pouch-style lithium-ion batteries [22].

Fig 29: Battery [22]

BLUETOOTH MODULE

It's a Bluetooth gadget that allows you to interact wirelessly. It is compatible with all Bluetooth-enabled devices. It uses serial communication to communicate with the Arduino board. AT commands are used to change the module's settings. This module is used to create a link between the mobile app and the microcontroller in this system. All of the commands that we used in the app are communicated to the Arduino via this module, and it performs all of its tasks as a result. We employ Bluetooth 5.0, which provides improved connectivity and range [22].

Fig 30: Bluetooth Module [22]

WHEELS

A wheel is a circular component that rotates on an axial bearing. The wheel is one of the six simple machines' primary components, along with the wheel and axle. Wheels and axles enable heavy things to be readily moved, aiding movement or transit while bearing a load or doing work in machines. Other uses for wheels include a ship's wheel, steering wheel, potter's wheel, and flywheel. Transportation applications are common examples. A wheel considerably minimises friction by facilitating motion through the use of axles. A moment must be delivered to the wheel about its axis in order for it to revolve, either by gravity or by the application of another external force or torque [22].

Fig 31: Wheel [22]

VOLTAGE REGULATOR

5V DC Voltage Regulator Data Sheet / Specs 7805 Voltage Regulator. The 7805 allows circuit designers to easily control DC voltages to 5v. The 7805 is a positive voltage DC regulator with only three terminals that is encapsulated in a single chip/package (IC). They are as follows: input voltage, ground, and output voltage. Despite the fact that the 7805 was intended primarily for a fixed-voltage output (5V). Data Sheet / Specs for 7812 Voltage Regulator 12V DC Voltage Regulator The 78012 allows circuit designers to easily control DC voltages to 12 volts.The 78012 is a positive voltage DC regulator with only three terminals that is encapsulated in a single chip/package (IC). They are as follows: input voltage, ground, and output voltage. Despite the fact that the 78012 was originally intended for a fixed voltage output (12V). It is possible to utilise external components with the 7812 Voltage regulator to get DC output voltages of: 5V, 6V, 8V, 9V, 10V, 12V, 15V, 18V, 20V, and 24V. It should be noted that the input voltage must, of course, be larger than the needed output voltage in order for it to be controlled downwards [22].

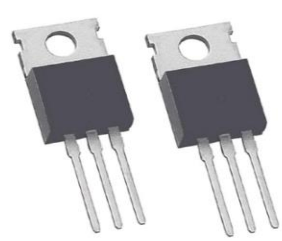

Fig 32: Voltage regulator [22]

EXPERIMENT WORKING SETUP

A wireless transmitter is placed in the wireless night vision camera of the robot. A cluster of infrared LEDs is employed to deliver IR light to the picture sources. The reason IR light is favoured is that it is normally dark at night, and since any camera requires light for lighting, infrared light is the best option because all things emit a range of Infrared light. The camera is powered by a 12 V battery and collects images before transmitting them to a receiver device attached to a television. The pictures are transformed to digital signals by the transmitter unit, and the digital signals are received and reconverted to images by the reception unit, which is then monitored and evaluated on a television unit.

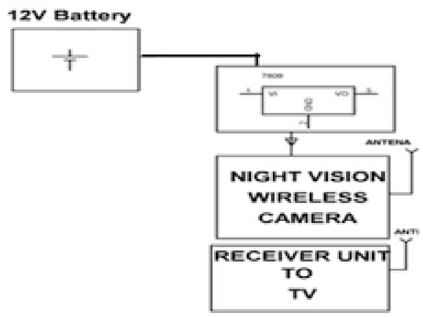

Fig 33: Block Diagram Showing Basic Working of the Robot with Night Vision Camera.

The robot is completely controlled remotely. It is made up of a transmitter part that sends the necessary data to the reception section. Covering the Robot is as simple as pushing a couple buttons on the transmitter side. The transmitter unit is made up of an encoder that takes parallel data from the microcontroller via the pushbuttons and sends it serially via the RF module. When a push button is pressed, the Microcontroller is configured to deliver necessary signals in parallel to the Encoder. The encoder turns these parallel impulses into serial signals that the RF module may send. This serial data is modulated with a carrier signal using an RF transmitter. When we push the left button, for example, the microcontroller delivers the command to the receiver unit through the encoder and the RF module. The receiver unit is made up of an RF receiver module that demodulates the received signal and a decoder that receives serial data via the RF receiver module and transforms it to parallel form.This data is used by the microcontroller to send an appropriate control signal to the motor driver IC, which controls the functioning of the two motors. Thus, by manipulating the motor, the robot may be pushed forward or backward while the camera continues to function.

TABLE 1: DESIGN OF CIRCUIT AND LAYOUT OF COMPONENTS

LIST OF ITEMS	NO.OF QUANTITY	SPECIFICATIONS
Motor driver	1	**L298**
Dc motors	2	**500MΩ**

Jumper cables	As required	-
Arduino (microcontroller)	1	**UNO**
Resistors	As required	-
servo motor	2	-
Arduino cable	1	**USB TYPE**
Power supply	1	-
Wireless camera	1	-
Buck converter	1	-
Battery	1	**LIPO**
Bluetooth module	1	-
Wheels	4	-

SOSTWARE AND TOOLS

The Arduino Integrated Development Environment (IDE) is a cross-platform (Windows, Mac OS X, Linux) programme developed in C and C++ functions. It's used to create and upload programmes to Arduino-compatible boards, as well as other vendor development boards with the support of third-party cores. The GNU General Public License, version 2 is used to licence the IDE's source code. The Arduino IDE has specific code structure guidelines to support the languages C and C++. The Wiring project is a software library that is included with the Arduino IDE and provides numerous common input and output processes. User-written code just needs two basic functions to start the sketch and the main programme loop, which are built and linked into an executable cyclic executive programme using the GNU tool chain, which is also included with the IDE release. The code was created in C and includes all of the essential functions to make the robot work properly.

TESTING

All of the connections are made correctly, and the output of the Spy-Bot is checked. Make sure there are no weak connections and that Spy-Bot move freely.

Fig 34: testing military surveillance robot

ASSEMENT COMPONENTS USAGE OF PIECHART

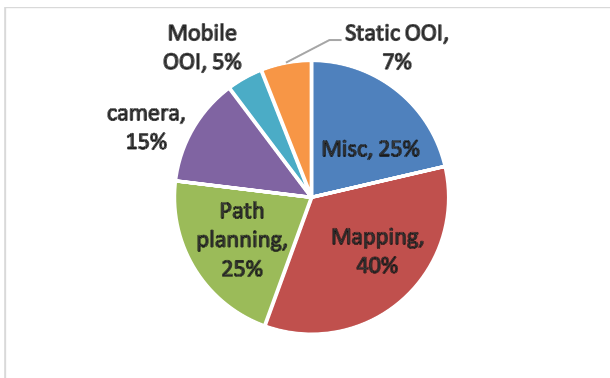

Fig 35: Assessment component usage in pie chart

This pie chart depicts the amount of calculation required when each of the software programme components is used. At the wheeled robot, separate modules are responsible for navigation, mapping, estimation, and concept, but only a few of these are used:

- **Path planning:** To fulfil the robot's dynamics, it simply calibrates the shortest path from the preliminary role to the goal role while considering the terrain.
- **Camera:** functions as the robot's sight, assisting in navigation and data transmission to the input module. It also takes care of detecting dangerous things in its route and tracking or escaping from them in real time.
- **Mobile OOIs' (object-oriented interface):** allows for the definition of real-time responses to sensor statistics and the synchronisation of the many actuators and sensors available, allowing for sensor-aware motion combinations. This also enables unrestricted movements depending on sensor statistics.

- **Static OOI:** The robot uses sensors in its path to detect static objects and makes appropriate adjustments to its path position to either get away from or interact with the object.
- **Misc:** or various, is the observation made when a robot performs actions and makes judgments on its own at predetermined intervals utilising built-in components and modules; this activity is completed on its own by statistical decisions.
- **Mapping:** The robot does this to interact with the surrounding environment and to locate itself. For coordination and information sharing, many sensors and estimate modules work together.

RESULT

The spy robot consists of a four-wheeled vehicle and a camera. At the front, two motors are placed into the vehicle's wheels, and at the back, only the wheels are inserted with no motors; depending on which way the front wheels move, the back side wheels will follow. The vehicle's front wheels are permanently fastened on an axis. The vehicle is capable of moving forward and backward, as well as left and right. The vehicle is capable of moving forward and backward, as well as left and right. The camera is mounted on the vehicle's head and may rotate to the left and right. Rotating the camera is meant to provide a more expansive picture. While the spy robot is motivating, the camera records video and audio and delivers it immediately and simultaneously to the user. It also includes a capture card for recording and storing video and audio from the camera transmitter. The capture card is then attached to the laptop. The user may watch the spy robot's perception of its surroundings and store it as a video clip for later reference. Although a lead acid battery may be recharged, it can only last an hour and detect within a 100-foot range.The user may also record when the robot is moving or resting by clicking the record button.

CONCLUSION

Earlier robots had the basic design to be effective, but due to restrictions in the materials utilised in them, the robot's usefulness was limited and dexterity was diminished. Even though the robot effectiveness is lower, the cost of the used equipment is slightly higher. The military's future technologies will be intelligent robots. We can lower the danger of death by using monitoring robots to save as much human power as possible, which we can put to better use elsewhere. We created a wheeled robot for military surveillance that allows us to keep an eye on the border. The number of a Jacobian matrix is used to do kinematics analysis. It was discovered that the optimal length of offset and radius of wheels are required to produce motions in all directions with equal effort. Robot kinematics are divided into two types: forward and inverse. We're using direct(forward) kinematics, which involves solving the forward transformation equation to get the robot's location in terms of angles and displacements between the connections. We can see and respond to the current situation in real time.

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APPENDIX

COMPILING CODE IN ARUDINO

The code developed is now compiled in Arduino IDE and checked for errors

```
#include <Servo.h>

int servoPin=5;

int servoPin2=3;

Servo myservo;

Servo myservo2;

int a=90;

int b=90;

int c=135;

int d=45;

int e=90;

int r1=9,r2=10,l1=11,l2=12;

void setup(){
```

```
Serial.begin(9600);
myservo.write(90);
myservo2.write(90);
pinMode(r1,OUTPUT); //right motors forward
pinMode(r2,OUTPUT); //right motors reverse
pinMode(l1,OUTPUT); //left motors forward
pinMode(l2,OUTPUT); //left motors reverse
pinMode(5,OUTPUT);
pinMode(3,OUTPUT);
myservo.attach(servoPin);
myservo2.attach(servoPin2);
}
void loop() {
if(Serial.available()){
char t = (char)Serial.read();
95
if(t == 'F'){ //move forward(all motors rotate in forward direction)
digitalWrite(r1,HIGH);
digitalWrite(r2,LOW);
digitalWrite(l1,HIGH);
digitalWrite(l2,LOW);
}
else if(t == 'B'){ //move reverse (all motors rotate in reverse direction)
digitalWrite(r1,LOW);
digitalWrite(r2,HIGH);
digitalWrite(l1,LOW);
digitalWrite(l2,HIGH);
```

```
}
else if(t == 'L'){ //turn right (left side motors rotate in forward direction, right side motors
//rotate in reverse direction for 100ms & stop)
digitalWrite(r1,HIGH);
digitalWrite(r2,LOW);
digitalWrite(l1,LOW);
digitalWrite(l2,HIGH);
delay(100);
t = 'S';
}
else if(t == 'R'){ //turn left (right side motors rotate in forward direction, left side motors
//rotate in reverse direction for 100ms & stop)
digitalWrite(r1,LOW);
digitalWrite(r2,HIGH);
digitalWrite(l1,HIGH);
digitalWrite(l2,LOW);
delay(100);
t = 'S';
}
else if(t == 'S'){ //STOP (all motors stop)
digitalWrite(r1,LOW);
digitalWrite(r2,LOW);
digitalWrite(l1,LOW);
96
digitalWrite(l2,LOW);
}
else if(t == 'a'){
```

```
 a=a+5;
myservo.write(a);
b=a;
}
else if (t == 'b'){
b=b-5;
 myservo.write(b);
}
else if (t== 'c'){
 c=c-5;
 myservo2.write(c);
 c=20;
}
else if (t == 'd'){
d=d+5;
 myservo2.write(d);
 d=45;
}
else if (t == 'e'){
e=e+5;
 myservo2.write(e);
 e=90;
}
}
}
```