DESIGN & DEVELOPMENT OF MECANUM WHEELED MOBILE 3D HUMAN MOTION TRACKING SYSTEM

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Abstract

Imagine a robot that effortlessly mirrors your every move, bridging the gap between humans and machines. This introduces an innovative robotics project integrating Kinect One technology with a Mecanum wheel system to enable precise human motion tracking. Our goal is to develop a robot capable of effortlessly following human movements, allowing for intuitive interaction and assistance in various environments. By leveraging the depth-sensing capabilities of Kinect One and the omnidirectional maneuverability of Mecanum wheels, our robot can adapt to dynamic surroundings with exceptional agility. This project combines cutting-edge sensor technology, advanced robotics algorithms, and human-centric design to create a truly immersive and interactive robotic experience. With its seamless integration of motion tracking and omni-directional mobility, our Kinect-enabled Mecanum wheel robot opens up exciting possibilities for applications in fields such as healthcare, entertainment, and assistive robotics.

1. Introduction

Have you ever wondered how robots can move in any direction without turning their bodies? It's all thanks to mecanum wheels! Mecanum wheels are a type of wheel that allows a vehicle to move in any direction by applying forces in a diagonal direction. This is achieved by the wheels having a special design that allows them to roll in a diagonal direction. Mecanum wheels were invented by Bengt Erland Ilon in 1972. They have a number of benefits, including:

Omnidirectional movement: Mecanum wheels allow a vehicle to move in any direction without having to turn its body.

Stability: Mecanum wheels provide a high stability, even moving at high speeds.

Easy to control: Mecanum wheels are easy to control, even for inexperienced users.

Mecanum wheels are a versatile and powerful tool that can be used in a variety of applications. They are an essential component of mobile 3D human motion tracking systems, and they have the potential to change the way we use computers and the world around us.

Here are a few examples of how mecanum wheels are being used today:

Virtual reality: Mecanum wheels are used in virtual reality headsets to allow users to move around in a virtual environment.

Gaming: Mecanum wheels are used in gaming robots to allow players to control the robot's movement.

Industrial robots: Mecanum wheels are used in industrial robots to allow them to move around a factory floor and complete tasks.

2. Driving Mobile Robot

The mobile robot can be driven the desired direction by rotating the mecanum wheel in the directions shown in Figure-1. The necessary kinematic calculations of mecanum wheels are mentioned in the theoretical calculation part.

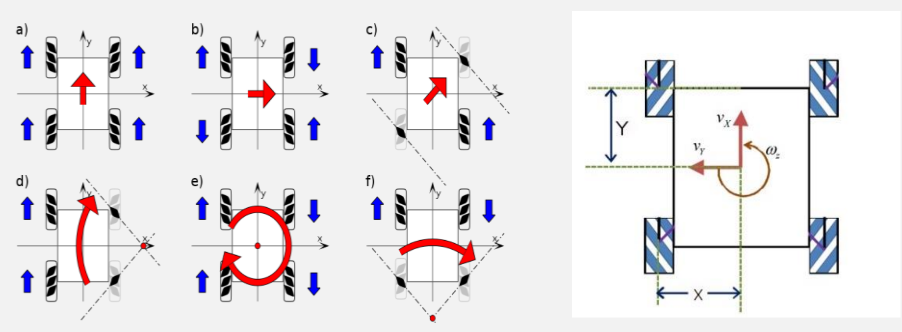


Figure 1: Directional Control of Mobile Robot

3.Theoretical Calculations

Vd (driving axis component of robot velocity) & Vs (free sliding axis of robot velocity), they will be given;

$$V_d = V_{y_{wheel}} + V_{x_{wheel}} \tan\beta \,,\; V_s = \frac{V_{x_{wheel}}}{\cos\beta}$$

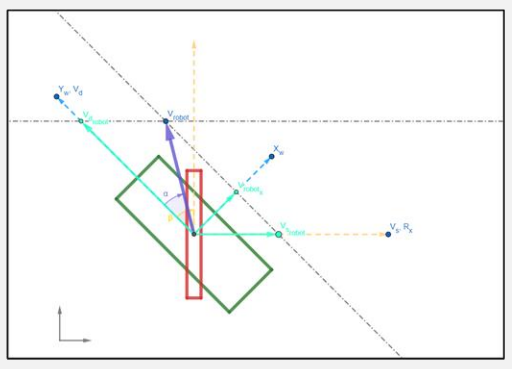
Where, $V_{x_{wheel}}$ is mecanum wheel's x axis component of V, $V_{y_{wheel}}$ is mecanum wheel's y axis component and β is angle between passive roller in wheel and wheel.

Also in matrix form of robot velocity representation is;

$$\begin{bmatrix} V_{x_{wheel,}} \\ V_{y_{wheel,}} \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 & y \\ 0 & 1 & x \end{bmatrix}}_{\substack{effect\ of \\ angular \\ velocity \\ (w_z)}} \underbrace{\begin{bmatrix} \cos\emptyset & -\sin\emptyset & 0 \\ \sin\emptyset & \cos\emptyset & 0 \\ 0 & 0 & 1 \end{bmatrix}}_{\substack{rotation\ matrix \\ about\ z\ axis\ for \\ mapping\ the\ velocities}} \underbrace{\begin{bmatrix} V_{x_g} \\ V_{y_g} \\ W_g \end{bmatrix}}_{\substack{velocity \\ about \\ ground}}$$

$$\text{Vd}=[tan\beta \quad 1]\begin{bmatrix} V_{x_{wheel}} \\ V_{y_{wheel}} \end{bmatrix},\; Vd = \frac{\omega}{r},\; \omega=\begin{bmatrix} \frac{tan\beta}{r} & \frac{1}{r} \end{bmatrix}\begin{bmatrix} V_{x_{wheel}} \\ V_{y_{wheel}} \end{bmatrix}$$

Then final equation is obtanined;



$$\omega_i = \begin{bmatrix} \frac{tan\beta}{r} & \frac{1}{r} \end{bmatrix}\begin{bmatrix} 1 & 0 & y \\ 0 & 1 & x \end{bmatrix}\begin{bmatrix} \cos\emptyset & -\sin\emptyset & 0 \\ \sin\emptyset & \cos\emptyset & 0 \\ 0 & 0 & 1 \end{bmatrix}\begin{bmatrix} V_{x_g} \\ V_{y_g} \\ W_g \end{bmatrix} \quad \textbf{(1)}$$

ω:rotation per minute [rad/sec], β: is angle between passive roller in wheel and wheel, x & y wheel distance from center of robot

Figure 2: Kinematic Representation of a Mecanum Wheel

4. Human Tracking

By using Kinect, human detection and information about the angle and distance of the human are obtained. With the angle and distance information received, the robot makes the angle zero and fixes the distance to the determined 2 meters. Also, using P control, the speed is controlled according to the distance and angle.

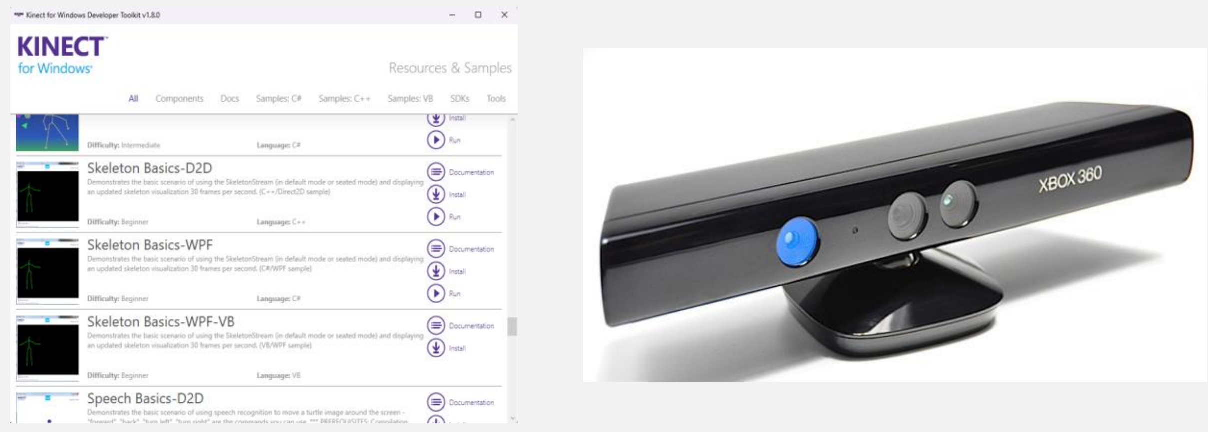


Figure 3: Kinect Tool Kit and Kinect

Speed values calculated with C# are sent to Raspberry Pi Pico. Pico rotates the wheels according to the speed values it receives. In addition, optical encoder is connected to the wheels and the actual speed is determined. Using this speed, PID control is performed to ensure that the wheels rotate at the correct speed. This cycle continues quickly. In this way, when a different one is made after the main movement, Mobile Robot makes a new calculation according to your movement and follows you step by step

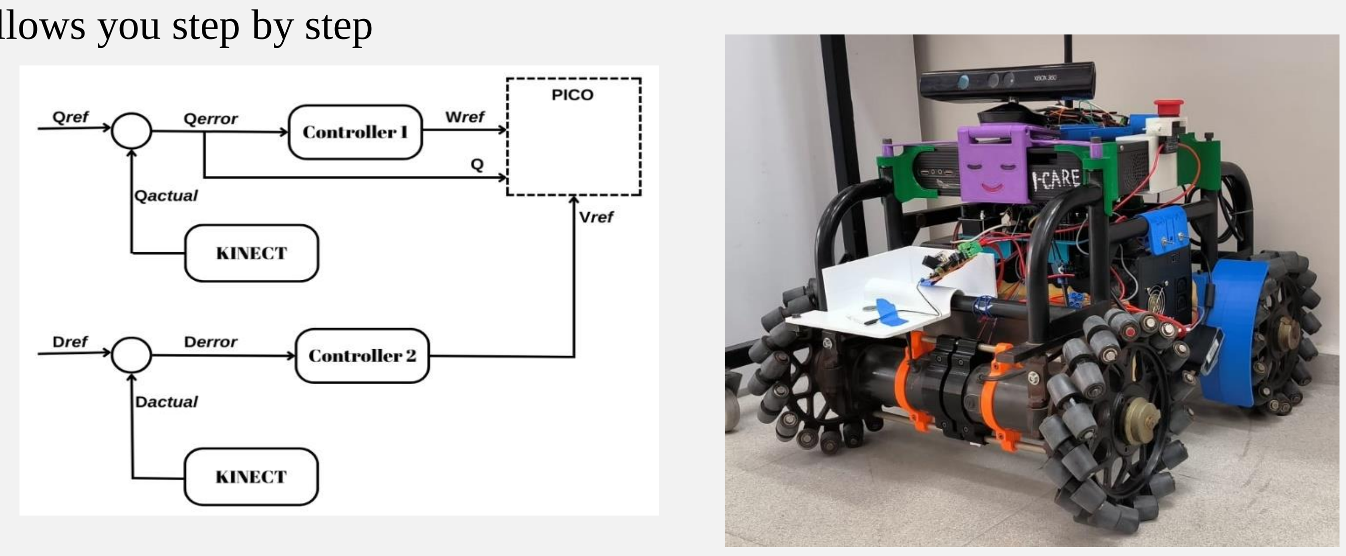


Figure 4: Block Diagram of Velocity Control System and Mobile Robot

5. Conclusions

Mecanum wheels were preferred in order for the mobile robot to move more easily in all directions and to be used in narrow and closed areas. Necessary kinematic calculations were made to control the mobile robot in the desired direction at the desired speed. The kinematic calculations were coded into raspberry pi pico. An encoder was added to the wheels. In this way, real wheel speeds were obtained. By finding the difference from the calculated wheel speed, an error was found. PID control was applied for each wheel using these values. Microsoft Kinect was added to the mobile robot. Distance and human position on camera was obtained.Using the P controller, the information at what speed and in which direction the mobile robot should go was calculated and sent to the pico card. In this way, the mobile robot centers human and keeping a certain distance are instantly provided.

References

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