The Effect of Kinematic Sensors on the Accuracy of an Autonomous Robot

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Abstract

As the field of automation in correspondence to kinematics is increasing its prominence among automobiles and intelligent machines, this research paper conveys the influence of three primary kinematic sensor arrays, four wheel drive encoder, two wheel odometry & IMU Gyro, and three wheel odometry, on the accuracy of an autonomous robot to attain its reference position. This was assessed through three primary kinematic procedures: a three-hundred sixty degree rotational assessment, straight 152.4 cm longitudinal extent assessment, and a spline curve assessment, integrating both components into one primary nonlinear curvature trajectory resembling that of an "S" shape. This was utilized to best resemble the primary kinematic trajectories utilized in society in which non-linear curvatures consist of greater prominence. The obtained data corresponded to the hypothesis, denoting the three-wheel odometry introduced the greatest autonomous accuracy, followed by two wheel odometry and four drive encoders. This was primarily due to the assessment of odometry wheels and their influence through dead wheel documentation in correspondence to their integration into the feedforward and PID algorithms. In addition, the implementation of dead wheels permits for the mitigation of discrepancies in the presence of physical obstruction thus introducing greater efficiency in susceptible circumstances of obstruction. Similarly, due to drive encoder discrepancies through traction and slipping, the tensioned odometry wheels consisted of greater individual accuracy and permitted for reliant data attainment to contribute to an enhanced autonomous procedure. Thus, this study has introduced substantial insights in the foundation of accuracy within autonomous kinematics and consists of a multitude of enhancements that advance automated kinematics within technological society.

***Keywords*:** Odometry, feedforward, kinematics, autonomous, encoders, PID

Introduction

Research Question
How does the implementation of kinematic sensors contribute to the accuracy of an autonomous robot?

Relevance to Society
As technological society is advancing through intelligent machines, primarily exemplified through the automobile industry, the primary objective is to attain the greatest accuracy regarding the utilization of sensors and software algorithms. As progression occurs in automated machines, primarily through kinematics and motion profiling, we must assess the ability to attain the greatest accuracy from the reference position to true position to further enhance these subsystems that are increasing their prominence in society. In addition, a multitude of citizens question the safety and accuracy of these automated machines thus substantiating the presence of this study and its influence on society. Thus, through pursuing this study, the advancing technological intelligent machines will be substantially enhanced to ensure further kinematic progression and promote scientific society.

Experimental Design
This study consisted of three independent variables regarding the sensor utilized and implemented referred to as four wheel encoders, two wheel odometry & IMU Gyro, and three wheel odometry. Due to the four wheel encoders consisting of integration within the drive motor and lacking external sensors, this independent variable component is most affiliated as the control. The dependent variable refers to the accuracy of an autonomous robot assessed through differentiated kinematic pathing procedures in which it outputs the longitudinal and rotational error, both distinct and in an integrated representation. In order to ensure consistency and efficiency within this research study, constants encompassed the subject of testing in which it is the robot, location of odometry wheels on the robot, testing environment, value of repeated trials for each procedure, and similar ideals. As a further method to increase validity and accuracy of this study, each procedure is repeated three times and the data is recorded. Following this, a mean error interval for each procedure is calculated and documented to compose a mean absolute error variable utilized in the accuracy assessment of the data.

Intended Data
Through pursuing prior research regarding these kinematic sensors and its efficiency within the feedforward and PID integrated algorithms.

Kinematic Sensors	**Proficiencies**	**Inefficiencies**
Robot Drive Encoders	➢ Essentially four sensors utilized thus the greatest value of sensors among the independent variables ➢ Relatively efficient in simple movement pathing and at limited acceleration and velocity	➢ Greater linear profiling within a curvature path ➢ Greater susceptibility of drift thus decreasing relative accuracy ➢ Reliance on drive encoders are primarily inaccurate due to drive wheel tractions complications
2 Wheel Odometry & IMU Gyro	➢ Consistent rotational accuracy due to internal IMU gyro ➢ Substantially accurate in linear pathing and simple curvature and rotational trajectories	➢ Consists of a relatively greater drifting probability as opposed to three wheel odometry ➢ Reliant on internal IMU Gyro regarding rotation thus PID cannot account for discrepancies due to lack of reference
Three Wheel Odometry	➢ Believed to consist of the greatest efficiency ➢ All components are data oriented in conjunction with accuracy of odometry wheels ➢ Substantially enhanced trajectory accuracy within curvature pathing due to the utilization of pose exponentials	➢ Tuning of heading is imperative and must be maximized to ensure the greatest accuracy ➢ Tension of odometry pods must be optimized to permit for greater trajectory documentation

Hypothesis
If three wheel odometry is implemented, then the accuracy of the robot will consist of the greatest enhancement due to the individual dead wheel documentation assessing critical data to contribute to an advanced feedforward algorithm and substantiated PID algorithm in addition to greater data attained through linear and rotational documentation.

Engineering & Scientific Objective
In this research study, the primary engineering objective is to attain a mean absolute error interval in the rotational, longitudinal, and integrated assessments below 3% of error.

Materials & Methodologies

Materials

There were a multitude of critical components utilized to maximize the ideals of this research study. This was primarily a technological entity in which it is a computer, a programming interface in which it is the Java programming language integrated with the Android Studio application, a subject of testing in which it is the robot, a validated testing environment, location of odometry pods and its interval of tensioning

Procedures

There were three primary procedures pursued to assess the pathing capabilities of the robot regarding its rotational, longitudinal, and integrated curvature trajectory ability. This was a rotational assessment in which the robot pursues a 360^0 rotation and the rotational discrepancy is calculated to the nearest 0.001 degree; assesses the rotational pathing components of kinematics and motion profiling, a straight line assessment in which the robot pursues a 152.4 cm straight line and the longitudinal discrepancy is calculated to the nearest 0.001 centimeter; assesses the linear pathing component of kinematics and motion profiling, and a spline trajectory assessment in which the robot pursues a spline curve, resembling that of an "S," consisting a 76.2 cm longitudinal extent in addition to rotation throughout the path; integrates both the rotational and longitudinal components to represent greater application to modern intelligent machines through these nonlinear kinematic pathing sequences to assess compatibility.

Data Interpretation

As the procedure is pursued, the corresponding longitudinal, rotational, and integral error will be documented. Following this, there will be ten representation graphs in which there are three regarding each procedure and the corresponding sensor data, and a finalized graph representing all components in which the independent variable is the sensor and it consists of individual data components regarding the mean absolute error of each procedure. This will then be represented on a graph through the utilization of a python library referred to as MatPlotLib to compose the graph in which the independent variables refer to the trials and its mean, and the dependent variable represents the interval of measurement in which the spline will consist of two y axes consisting of rotational and longitudinal discrepancies.

Susceptible Concerns

The greatest critical concern regarding this research study is primarily oriented throughout the robot due to the presence of an automated physical subject of testing thus introducing safety concerns. However, due to the embedded protocols within the control hub and an implemented control switch, these concerns are primarily mitigated to a great extent. The external components primarily regard a digital interface thus there is lack of concerns within this component of research.

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