Analysis of the behavior of a mobile robot with precise and fuzzy pid controller in an uncertain environment

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Abstract.
The aim of this study was to develop methods for building intelligent systems that ensure safe movement on a planned and specified trajectory in an environment with unknown obstacles for planning the movement of a mobile robot. To achieve this goal, modern concepts and methods of planning systems development were analyzed. By moving a mobile robot in an unknown environment, it is proposed to develop an intelligent system for planning its modeling in an uncertain static environment, to realize an intelligent system for planning the movement of a mobile robot in an unknown dynamic environment and modeling the resulting system. As a result, analytical studies were conducted on a computer using mathematical modeling, analytical geometry, kinematic and dynamic analysis, fuzzy logic, neural networks, robotics, mechatronics, discrete integration and applied programming methods, and experimental studies were conducted using a mobile robot model.

Keywords:
Mobile robots
robot motion planning
agent hardware
intelligent systems
optimization approach
1. INTRODUCTION

An intelligent hybrid fuzzy PID controller structure is explained in [1], which is a mixture of classical PID and fuzzy control in an intelligent way. Basically, in this design method, a classical PID controller and a fuzzy controller are combined with the help of a ranking mechanism related to the function related to the error occurring in the system. In addition, the intelligent switching mechanism is used to decide which controller (Classical PID or Fuzzy Control) will be used first in the control action of the ranking mechanism.

Simulations are performed for various systems with the new intelligent hybrid controller architecture and the evaluations show that it outperforms both controllers (classical PID and Fuzzy controller) in both transient and steady state response. Control parameters are determined with the help of genetic algorithms. In the study conducted in [2], the adjustment of the PID coefficients of the pitch angle controller of the wind turbine blade with a fuzzy logic algorithm was considered. The classical PI, fuzzy control and fuzzy PID controller aim to avoid damaging the system and maintain the rated output power at high wind speed by using three different control methods. By simulating the control with Matlab/Simulink software, it aims to control the pitch angle of the wind turbine blade at different wind speeds and keep the thrust force constant at the set point.

The stabilization time and steady-state errors of the output power obtained from the simulation results were evaluated, and the performances of the control systems were measured and compared with each other. Among the established results, Fuzzy PID controller is found to perform better than PI and Fuzzy controllers. In the study conducted in [3-5], it was shown that it is possible to combine intelligent management systems with traditional management structures, and this combination will combine the advantages of two different management strategies, both theoretically and practically. In this type of controllers, the design can be done according to one point or the degree of freedom can be increased by adjusting according to more than one point. The design stage of fuzzy controllers can be divided into two main groups: structural and adjustment parameters. Structural parameters include input-output units, membership functions.
defined by linguistic variables, rules, fuzzy inference, and fuzzification mechanisms. The tuning parameters consist of input-output scaling and membership function parameters. Although the project can be done by one of these points, it can also be done according to more than one point. As in the design phase, it is possible to improve the efficiency of fuzzy controllers by methods such as optimization or customization [6].

The output of closed-loop system of self-adjusting fuzzy controller of missed project point is error signal, confirmation signal, etc. bound to a linear or non-linear function that can take their derivatives and integrals as input. Unlike tuning parameters, it is possible to adjust structural parameters. This thesis covers online self-adjustment of coupling operator in inference mechanism for fuzzy PID controllers as a completely innovative idea. Thus, it is aimed to increase the efficiency of management by showing that structural parameters can be used as regulatory parameters. In this study, one free parameter Gamma operator was used as the coupling operator.

The study in [4,7] aims to develop the tuning methods for the fuzzy rule weights of the fuzzy PID controller. In this direction, two different fuzzy rule weighting methods are proposed. These rule measurement methods use system knowledge and methods are discussed online. Since the proposed methods have a general structure, they can be applied to any type of system. In the first of these rule measurement methods, only the error information of the system was used. In the second, a single acceleration variable is used, which provides information about the system speed in addition to the error information. The proposed methods were first applied to some linear and non-linear test systems in the Matlab environment and studied through simulations. It is a well-known fact that some differences in performance may occur as a result of applying the controller structure developed in the simulation environment in physical systems. In this context, in addition to simulation applications, the proposed fuzzy PID controller structures are also implemented in real-time in the Process Control Simulator and pH Control Experiment Series.

With the rapid development of artificial intelligence, the application of artificial intelligence robots has become
an attractive research topic. Regardless of the role of the AI robot, learning performance is the variable most highlighted in the AIRE study.

In this work, it is considered to build a ground control model of an autonomous robot in a stable runway environment with a fuzzy controller approach. With the fuzzy controller approach, it is studied that the robot moves easily in the test environment and goes to desired targets. The objective is to minimize the energy consumption of the robot with an autonomous mobile robot fuzzy controller algorithm [8].

The energy consumption for processing time and the data error between the coordinate where the robot should go and the coordinates it goes after the operations are completed are calculated separately. Introduction After learning the environment, when the robot is operated in the task area, it creates a map of the environment by detecting the distances of objects around it and calculates its location by comparing it with the maps in its memory. Calculating the starting location, the robot continuously scans its surroundings en route to a given target point and advances to the target point using the encoder information it receives from the wheels. On the way to the goal, the ant colony tries to calculate the shortest path using the measurement points in its memory. Unmanned vehicles are technologies used in critical areas that do not have human elements, can be controlled remotely or autonomously, and perform predefined tasks. Perhaps the most fundamental driver of demand for unmanned vehicles is that they can be sent anywhere humans cannot safely go and return. In this work, the data sent to the mobile robot was subjected to a planned navigation process and the robot was ensured to work in the direction of the received target information without loading the map data. In planned navigation, the robot collects information from the environment through ultrasonic sensors and infrared sensors, makes a plan according to the received information, and acts on this plan. Simulation work was carried out on the runway with the software created in MATLAB environment, and the test results were compared with the MATLAB results.

2. SETTING THE ISSUE

Defining the input and output parameters of the mobile robot:
Designed fuzzy logic unit;
1. Input variables:
   - X location (cm) = Location data on the x axis of the robot between 0 – 100 cm.
   - Y Location (cm) = Location data between 0 – 100 cm on the y-axis of the robot.
   - Angle (º) = Ground angle data of the mobile robot with respect to the axes.
2. Output variable:
   - Distance (cm) = consists of X and Y location data and system output data related to angle data.

3. SOLUTION OF PROBLEM
Affiliation operations
Fuzzy subsets for both input and output variables of the mobile robot are defined as triangular and trapezoidal membership functions.
Variations of X location, Y location and Angle variables:
0<X position<100
0<Y position<100
0<Horizontal Angle<90.
Membership functions corresponding to intervals (Fig. 1-4):

![Figure 1: Fuzzy Subsets of X-Spatial Data](image1)

![Figure 2: Fuzzy subsets of Y position data](image2)
Ranges of distance data as an output variable are: 
0<Distance<130.

The membership functions corresponding to these intervals are given below.

**Fuzzyfication.** Fuzzy rules are the most important part of fuzzy logic control unit. Because in this section, the knowledge base and decision-making ability of the Mobile robot are created. There are many techniques for creating fuzzy reasoning. For any input, each rule is used with a certain degree of severity. Max-Min (Mamdani) fuzzy extraction was chosen in Mobile robot to perform the work. In this method, the output fuzzy set is formed as a result of logic and processing of the input sets. The value of the output number is determined by the weighted average method.

**Defuzzyfication.** The information received from the output of the fuzzy logic control unit of the mobile robot is fuzzy information. To convert this fuzzy price into an accurate
price, it needs to be smoothed. First, each fuzzy output set of membership values for each rule used is searched in the output universal set. Then, one of the smoothing methods is used on the logical combination formed by these sets, and the smoothing process is carried out by finding the output value. The received value is the output value that the fuzzy logic controller will apply to the system. The data obtained from the fuzzy extraction of the mobile robot is used in the fuzzy section using the center of gravity method, which is widely used in fuzzy logic.

The algorithm for working in a fuzzy system for a mobile robot in Matlab environment is given below (fig. 5):

![Algorithm of operation of mobile robot in fuzzy system in Matlab environment](image)

**Figure 5**

Algorithm of operation of mobile robot in fuzzy system in Matlab environment

### 3. CONCLUSIONS

Two different control methods, fuzzy approach and traditional control method, were developed and system tests were carried out to control the mobile robot. The most important advantage of the mobile robot software and hardware
for the user is that their actions can be performed simultaneously. For both control methods used, the coordinate data to which it will go depending on the trajectory are not predetermined.

According to the obtained results, it was seen that the method using the fuzzy approach works ten times faster and more accurately than the traditional method. Being open to development and modular, the mobile robot has fulfilled the tasks intended for this release.

References:


pomoschyu-robotizirovannyh-datchikov-so-smartfonami
