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TECHNICAL NOTE

Fuzzy logic controller with slip detection behaviour for Mecanum-wheeled AGV

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SUMMARY

A fuzzy logic controller for an omni-directional, autonomous guided vehicle (AGV) implementing Mecanum wheels to achieve directional control of its motion is presented. Omni-directional robotic platforms advantage over conventional designs is that they are capable of performing tasks in congested environments. The AGV's behaviour during navigation is controlled using a fuzzy logic controller, with slip detection.

KEYWORDS: Fuzzy logic; Mecanum wheel; Autonomous guided vehicle (AGV); Inertial navigation; Collision avoidance; Behaviour-based control.

I. INTRODUCTION

Omni-directionality can be achieved by implementing different kinds and setups of wheels.[1] Mecanum wheels use slip between rollers, surface and ground to achieve omni-directionality (Figure 1).[2]

Navigation of omni-directional AGVs can be achieved by implementing a hybrid approach that combines model-based and sensor-based approaches. Optimality of model-based approaches and reactivity of sensor-based approaches are preserved.[3] Fuzzy logic technique is used for fusing robot behaviours and interpreting noisy sensor signals.

II. NAVIGATION IMPLEMENTING FUZZY LOGIC

A Mecanum-wheeled AGV platform with following sensory (inputs) and actuator (outputs) circuits to facilitate navigation and slip detection is developed: body-inertial sensor, laser-scanner, wheel-encoders, no-load battery-voltage sensors, AC RF voltage sensors and DC servo-motor controllers. (Fig. 2). There are three basic questions for the problem of navigation of mobile robots: "Where is the robot?", "Where is it going?" and "How should it get there?".[4]

Outputs from different sensory circuits and inputs to actuator circuits are converted into fuzzy values between zero and one, using membership functions. Nine sets of membership functions are used; six inputs (i.e. object-distance (OD), object-angular position (OAP), vehicle-speed (VS), wheel-speed (WS), AC RF peak voltage (AC RF V)

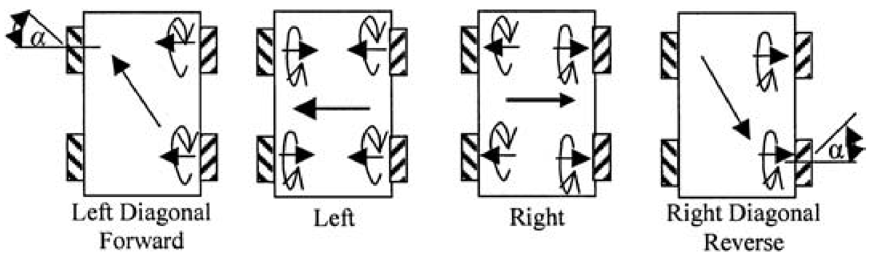

Fig. 1. Directional Control of a Mecanum-Wheeled AGV. Right-Hand Used to Determine Direction of Rotational Speed. Roller Angle α is Shown. Note: Change in Direction of Motion of AGV can Be Achieved Without Changing its Orientation if Necessary.

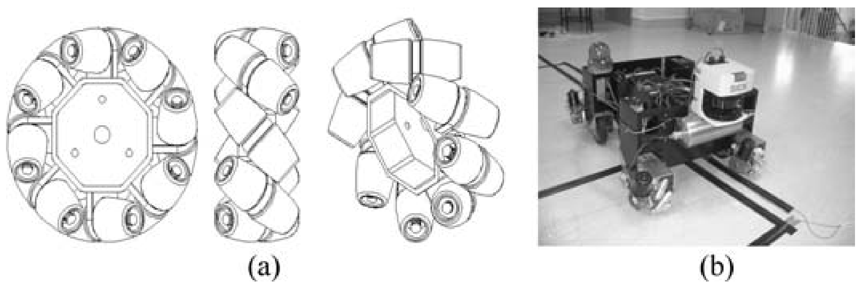

Fig. 2. (a) Mecanum Wheel Design With Centrally Mounted Rollers, Rollers Can Rotate About Their own Axis to Reduce Friction. (b) The Developed Mobile Robot.

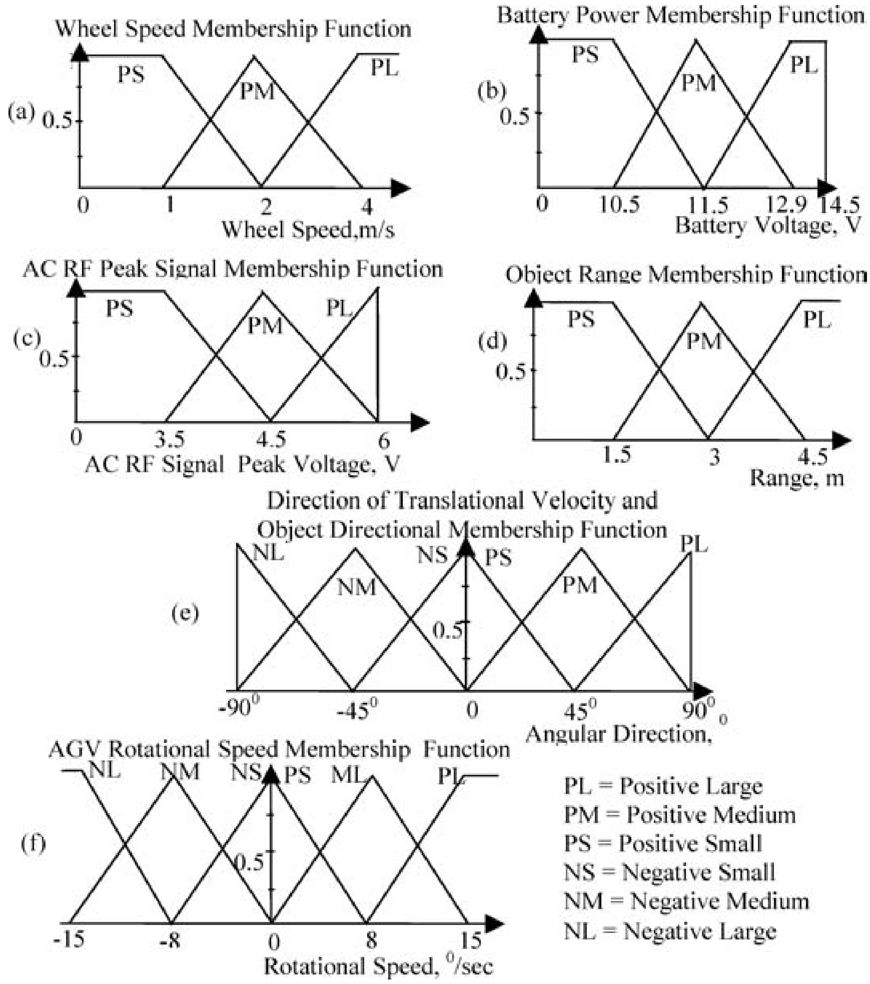

Fig. 3. Membership Functions for: (a) Speed (Based on the Wheel Encoders Circuit), (b) Battery Voltage (Based on the No-Load Voltage Monitoring Circuit), (c) AC RF Signal for Line-Following (Based on AC RF Signal Circuit), (d) Obstacle Range (Based on the Laser Scanner System), (e) Directions For the Object and AGV's Motion (Based on the Laser Scanner and Inertial Systems Respectively), (f) Angular Rotational Speed (Based on Inertial Sensor).

and No-Load Battery Voltage (BV)) and three outputs (i.e. translational-speed (TS), direction of translational-velocity (DTV) and rotational-speed (RS)) (Fig 3).

For a fuzzy logic system, the rule-base defines the required outputs for any given combinations of inputs. In converting the rule-base, the rules are expressed as simple IF-THEN rules, for example:

IF

$\{(Object\,Range = PS)\,\&\,(Object\,Angular\,Position = NL)\,\&$

$(Vehicle\,Speed = PL)\,\&\,(Wheel\,Speed = PL)\}\,\&\,(ACRF$

$Peak\,Voltage = PS)\,\&\,(No\,Load\,Battery\,Voltage = PL)$

THEN

$\{(Translational\,Speed = PS)\,\&\,(Direction\,of\,Translational$

$Velocity = NM)\,\&\,(Rotational\,Speed = PM)\}.$

III. CONCLUSION

A fuzzy logic controller is used to achieve navigation and stable motion of a Mecanum-wheeled AGV on slip and non-slip surfaces. Tests conducted in order to determine the effectiveness of the developed controller are: obstacle-avoidance, target-seeking, wall-following and line-following behaviour tests.

Control over AGV can be maintained by avoiding surfaces with less friction or by implementing appropriate behaviour to avoid collision on such surfaces. The performance of system is dependent on shape and membership of fuzzy sets, which are derived heuristically. Other methods, such as neural-networks, genetic algorithm or iterative solutions can be used to optimise the controller performance.

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