ATIS-bots RoboCup@Work 2019 Team Description Paper

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Abstract— This paper addresses a description of MRL@Work team and a robot which is designed in the MRL laboratory. We describe the current state of the team with respect to mechanical parts, hardware and software architecture. The mechanic of the robot is designed and manufactured in this laboratory. A high-performance hardware has been employed to run all software parts and designed algorithms on this robot without any exterior computers.

Index Terms—RoboCup [at]Work, Team Description Paper, MRL, Mobility, Mobile Robot, robotic arm.

1 INTRODUCTION

MRL Mechatronic Research Laboratory is located in Qazvin Islamic Azad University research and innovation Center – Syntech, in which several teams have focused on robotic and AI research and challenges to contribute new technology and to participate in RoboCup competitions annually.

"MRL-@Work" is a team consist of undergraduate and graduate students and an assistance professor as team supervisor. The vision of this team is to design and build a robust intelligent autonomous industrial robot.
We have designed a UGV – unmanned ground vehicle – robot, called "AtisBot" composed of two distinguished parts; an Omni-directional base[Fig.1] and a 5DOF robotic arm. The arm's

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manipulation and the base's navigation have professionally performed in two year passed We are going to work on grasping system, decision making and task scheduling as well as fault toleration of our system in this year.

2 SYSTEM DESCRIPTION

*A. **Mechanics***

A.1 Robot Locomotion is based on 4 Mecanum wheels tracked system because it is common capable to transport in industrial flat ground [Fig. 1].

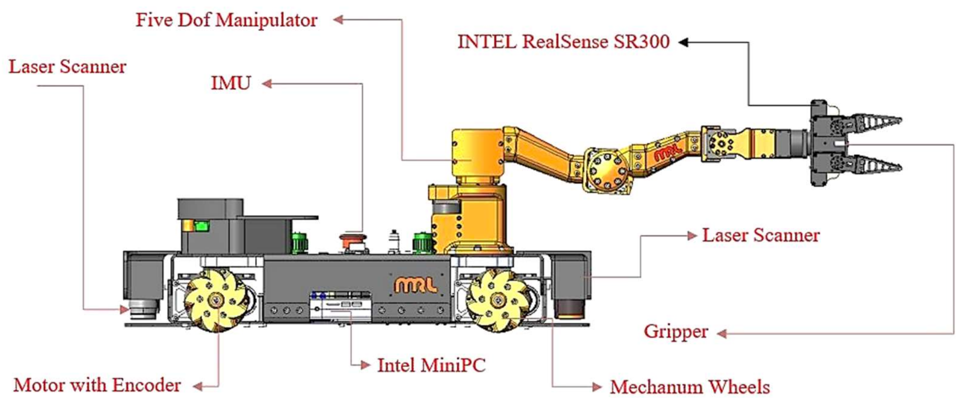

Fig. 1. MRL@Work Robot

A.2 Dynamic Analysis of Robot is evaluated using the kinetic and potential energy expressions, and applying Lagrange's equations for a constrained or unconstrained mobile robotic system. A simplified model in which the minimum torque is required for traction with slope of 6 degrees. In order to avoid a cumbersome analysis, it is reasonable to choose the input torques that they suffice the highest torques assumed to be applicable to the system.

A.3. Power Transmission is driven by four FaulHaber DC motors (90W) for main movement of the robot. The maximum speed is considered 1.2 m/s in frontal. We have used Spur gear for reducing the velocity and have used Ball bearing for absorbing the Mecanum wheels load shock.

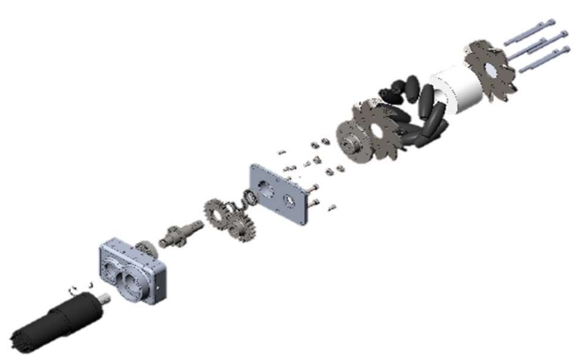

Fig. 2 Power Transition Gearbox Assembly

A.4. Manipulation has been done 5 DOFs which can reach to 70 cm distance. This manipulator has 2DOFs link for end-effector, and main links rotate with 120 degrees/s without considering destructions. Manipulator structure has been made by aluminum cast. Dynamixel Pro has been employed for manipulator actuator system because they are very small and low backlash. First link (Yaw) motor connected to 1:2 spur gearbox because Lagrange's equations in slope has calculation and used taper roller bearing for absorb energy when robot is in slope.

A.5. Grasping Mechanism has been done new structure with Dynamixel XM430-W350R and manufactured in the lab. This system includes passive gripper and force Sensor for force feedback. This mechanism can grasp and lift with payload up to 0.5Kg.

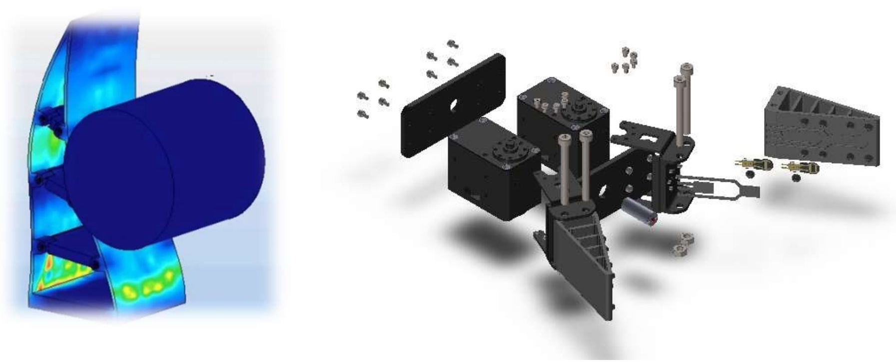

Fig. 3 Adaptive gripper static analysis

B. Hardware

B.1. MINI-PC:

Regarding to problems on communication for sending sensory rapidly such as laser, images and etc., an Intel Core i7 mini pc is considered to handle all software algorithms on the robot. This system can handle the proposed localization system which is based on three sensory laser scanner, IMU and a vision system. Fig 4 shows the hardware and their connection as completely. An embedded arm control system interfaces the motors of locomotion to the mini pc. This system communicates via cabled LAN to high level controller such as planner or navigation parts.

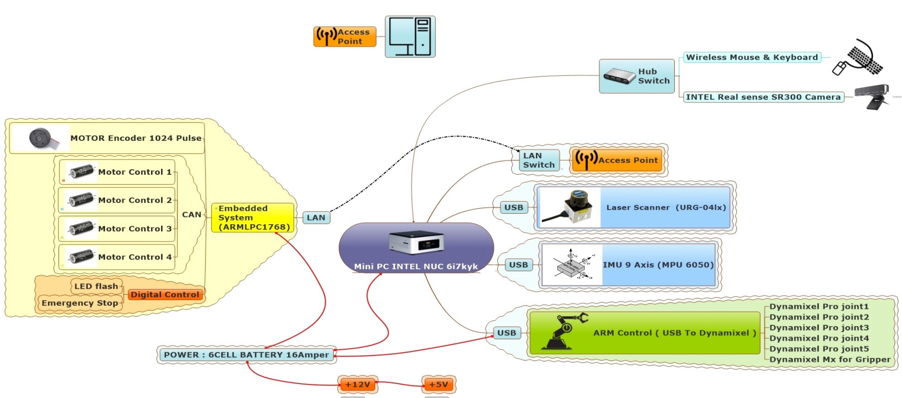

Fig 4. Hardware Diagram

Due to using of Dynamixel pro motor as shown in [Fig. 4] for arm, it would be directly control by manipulator control that is in the computer.

B.2. Electronics:

The low level robot control has been designed based on ARM-Cortex M3 microcontroller LPC1768. This unit consist of Ethernet, CAN and RS485 interface in order to communicate with driver motors, digital controller and wireless device. Also, we have used motor drivers for velocity control and PID control. Another board has been used to change input voltage to +5, +12, +24. Correspondingly, due to check the sensor, motor and other devices current behaviors can be monitored and logged. As shown in [Fig 4.1] our plan is to insert FSR sensors on the fingers to improve grasping system and to detect of failure occurs. In addition, the torque can be regulated as well depending on the object that is grasped by these sensors.

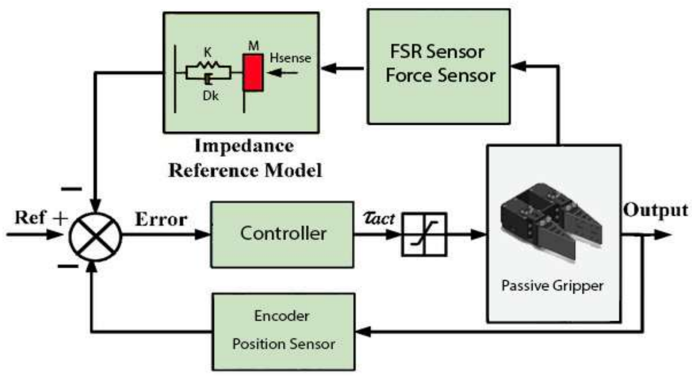

Fig 4.1 Gripper FSR Block Diagram

C. Software

The software architecture is shown in [Fig. 5.], most of the developed software tools are stand-alone, middleware agnostic, in which some packages are integrated within Robot Operating System (ROS) [4] by suitable wrappers. Since ROS is a flexible framework for writing robot software MRL[At]Work software infrastructure has been established based on the ROS Indigo middle-ware running on Ubuntu 14.04.

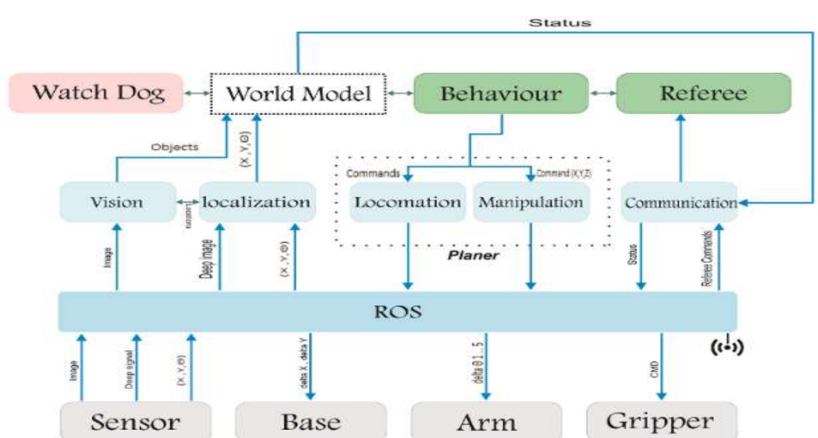

Fig. 5. Software architecture

It is a collection of tools, libraries, and conventions that aim to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms. The navigation stack is based on Occupancy Grid Map (Using ROS) with a global planner that provides a global path for navigating the robot on that path based on the standard Move Base ROS package.

C.1. Navigation and path Planning are the main task of a mobile robot. Arm trajectory and grasping of objects are additional task in [At]work robots. So, the robot must collect information regarding to the environment consisting its position and object positions, floor marks, industrial materials and other points of interest. In order to achieve these goals, a highly modular system has been developed. It consists of several layers such as behavior control, global path planner and trajectory generation. The high-level behavior of the robot chooses between moving towards marks and objects as well as exploring in the environment. The global planner task is to find the goal points with the aim of maximum coverage and minimum distance travelled. It tries to find the shortest tour which covers the whole environment. And local planer task is to find trajectory for arm for picking up object from source and putting down in destination. In contrast to other path planning methods, like wall following [5] or frontier exploration [6], the presented method significantly increases the performance of the robot. Moreover, recovery behaviors [7] also have been developed so that when the robot is having a collision, they take over and handle the situation.

C.2. Behavior: Currently, the MRL[At]Work robot is able to localize itself and safely navigate towards a selected target area, Recognize and localize objects using RGB-D sensors in Gazebo simulation and perform simple visual-serving and manipulation tasks. Many robot application, especially in competitions, have been developed using finite-state machines (FSM) and we follow the same approach as well as use task planners.

C.3. Vision: The vision system is divided into two parts include object recognition and localization, in which an Intel RealSense SR300 has been used. A camera is mounted on the arm for object recognition which transfers RGB-D data as image and depth of scene to the vision system. A segmentation algorithm based on [8,9] isolates objects from background. Then that the objects are detected and recognized based on the SURF features and SVM classifier. The location of objects from the end-effector is computed using 2-D image for X, Y and Depth for Z after object recognition. In second part, barrier tapes and tags are detected for two aims recognition of virtual walls as well as vision based localization. Vision base localization part has not been completed yet.

A ROS based system is used with a Laser scanner and an IMU for localization [10,11]. Moreover, some factors associated with indoor environment that can affect to collision of robot. So, for collision avoidance there is a vision based obstacle detection in the rare of robot.

C.4. Communication: The robots have been equipped with Cisco Linksys WAG120N Networks 802.11a/b/g/n Access Point/Bridge. Choosing IEEE 802.11a 2.4 GHz standard has allowed achieving the maximum efficiency without having the difficulties of 802.11b and 802.11g. 100MW power ensures robust signal to overcome long distances. For controlling mobile robot, video streaming, system diagnostics, sensors feedback, visualizing procedures and localization and mapping in a remote station are the most common usages of this type of communication.

C.5. Robot's Base: In the base of proposed robot omnidirectional wheels have been used which they provide ability for this base to move in any direction immediately without any rotation. Moreover, three sensors laser, wheel encoder and IMU have been used, and they are fused with EKF algorithm to increase the accuracy of robot localization. We have already applied Hector Localization and Hector Mapping by using an IMU and URG-04 laser scanner for localizing the robot in the filed as well as for generating the maps. Hector Localization is provided with IMU messages and pose update topic from the Hector Mapping node. These tools are linked to a skill manager and behavior controller to navigate the robot regarding to the obstacle avoidance. In addition, a vision based flag detector by using a Real sense camera (SR300) is employed due to virtual wall avoidance during robot movement. Currently we are tuning and testing the robot localization and navigation to increase the accuracy of experiments.

C.6. Task Scheduling: Robot had to do several tasks in a few time in particular final round. Regarding to the time limitation, it need to schedule and order the tasks in priority that the robot can do and income more Points. To do this, MRL@work team have employed a customized decision tree which is work somehow well, while it cannot find optimum schedule. Due to complexity and large search to find the best and optimum schedule, we are going to use meta-heuristic algorithms such as GA [14] or PSO[15] to tackle this problem.

3 ACKNOWLEDGEMENTS

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APPENDIX A

TEAM MEMBERS AND THEIR CONTRIBUTIONS

Vahid Rostami	Team Supervisor
Pouya Mansournia	Mechanical/Electrical Design
Anmar Ghazi Akar	Robot SLAM, Software
MohammadAli Kamkar	Software/ Arm Control
Faraz Jalili	Navigation, State Machine
Meran Mehralian	Software/ Vision
Qazvin Islamic Azad University	Sponsor

APPENDIX B
LISTS

A. System List

Table **I** list several features of this robot with manipulator system.

TABLE I

Attribute	Value
System Weight	**25Kg**
Overall Length	**550mm**
Overall Width	**380mm**
Overall Height	**140mm**
Minimum velocity	**0.1m/s**
Maximum velocity	**1.2m/s**
Height	**750mm**
Payload	**0.5kg**
Structure Material	**Aluminum cast**
Position repeatability	**5mm**
Communication	**Ethernet-CAN**
Voltage connection	**24V-DC**
Arm Link Speed	**120 degree/s**

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