The Framework of BeeBot: Binus Multi-Client of Intelligent Telepresence Robot

Widodo Budiharto, Muhsin Shodiq, Bayu Kanigoro, Jurike V. Moniaga, Hutomo

Abstract—We present a BeeBot, Binus Multi-client Intelligent Telepresence Robot, a custom-build robot system specifically designed for teleconference with multiple person using omni directional actuator. The robot is controlled using a computer networks, so the manager/supervisor can direct the robot to the intended person to start a discussion/inspection. People tracking and autonomous navigation are intelligent features of this robot. We build a web application for controlling the multi-client telepresence robot and open-source teleconference system used. Experimental result presented and we evaluated its performance.

Keywords—Telepresence robot, robot vision, intelligent robot.

I. INTRODUCTION

TELEPRESENCE robots can be deployed in a wide range of application domains, e.g. in workplaces, the public sector or for home use. The idea of a mobile telepresence robot stems from the inherent limitations imposed by traditional videoconferencing systems, in which interaction is restricted to the meeting room only. Telepresence robots are already being used in manufacturing industry, or hospitals to allow doctors and specialists to give consultations from afar. Telepresence robots can also be used to give people with restricted mobility a new way to outreach and interact beyond their usual living quarters[1][2][3]. In office or factory, sometimes manager/supervisor wants to discuss /supervise staffs remotely. So, telepresence robot with support multi-client can be used in this scenario.

Based on the literature study, some of the telepresence robot that has been built before for special needs such as patients and students, and were not focusing on the teleconference in office and autonomous navigation using stereo vision, such as [11][12]. State of the art of this research is to propose the framework of a multi-client intelligent telepresence robot called BeeBot. This robot can be used in office/factory with the features such as video teleconferencing using JITSI framework, people tracking, obstacles avoidance and fast movement using omni wheel mechanism.

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II. PROPOSED SYSTEM

A. Kinematics Model of Omni Wheels Robot

A holonomic or omni-directional robot is capable of driving in any direction. If we want to prescribe the robot's movements in the environment, we need to know how these variables relate to the primary variables we can control: the angular positions and velocities of the wheel shafts. Therefore, a kinematical model of the robot has to be developed. A global frame [x, y] represents the environment of the robot and the robot's location can be represented as (x, y, θ). The global velocity of the robot can be written as $\dot{x}, \dot{y}, \dot{\theta}$. We can also define a local frame $[xL, yL]$ that is attached to the robot itself. The center of this local frame coincides with the center of gravity of the robot. The three omni-wheel are located at an angle α_i (i= 1, 2, 3) relative to the local frame as shown in fig. 1. If we take the local axis xL as starting point and count degrees in the clockwise direction as positive, we have $\alpha_1 = 0°$, $\alpha_2 = 120°$ and $\alpha_3 = 240°$.
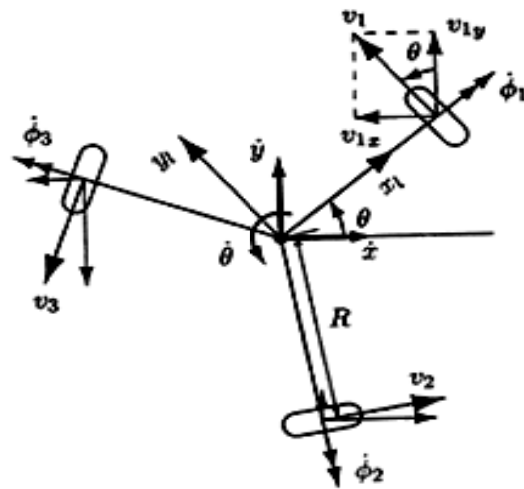

Fig. 1 Kinematics model of omnidirectional wheels[7]

The translational velocities of the wheels v_i on the floor determine the global velocity of the robot in the environment $\dot{x}, \dot{y}, \dot{\theta}$ and vice versa. The translational velocity of wheel hub v_i can be divided into a part due to pure translation of the robot and a part due to pure rotation of the robot.

$$v_i = v_{trans,i} + v_{rot} \qquad (1)$$

When the platform executes a pure rotation, the hub speed v_i needs to satisfy the following equation:

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$$v_{rot} = R\dot{\theta} \tag{2}$$

Here R is the distance from the center of gravity of the robot to the wheels along a radial path. The angular velocity of each wheel are:

$$\dot{\phi}_1 = (-\sin(\theta)\cos(\theta)\dot{x}_L + cos^2(\theta)\dot{y}_L + R\dot{\theta})/r \tag{3}$$

$$\dot{\phi}_2 = (-\sin(\theta+\alpha_2)\cos(\theta)\dot{x}_L + cos(\theta+\alpha_2)$$
$$\cos(\theta)\dot{y}_L + R\dot{\theta})/r \tag{4}$$

$$\dot{\phi}_3 = (-\sin(\theta+\alpha_3)\cos(\theta)\dot{x}_L + cos(\theta+\alpha_3)$$
$$\cos(\theta)\dot{y}_L + R\dot{\theta})/r \tag{5}$$

For control, we have the angular positions ϕ_1, ϕ_2, ϕ_3 and the velocities of the wheel shafts $\dot{\phi}_1, \dot{\phi}_2, \dot{\phi}_3$ at our disposal by changing the value to the PWM controller.

B. System Specification

The BeeBot platform is based on the Propeller processor with 3 omni directional wheels from Nexus Robot. A pole is fitted on the base plate and serves as the elevated attachment point for the 11" laptop, speakers,1 camera for pointing forward for conversations, 1 internal camera in laptop used for people tracking and obstacle avoidance, and can be used to extract additional features from the environment. The robot has an overall height of 130 cm, the size of a small person, allowing for natural conversation while standing or being seated. Additionally, Obstacle avoidance is implemented using 4 ultrasonic sensors using Fuzzy type-2 that able to handle the uncertainties, which provides assistance during manual operation or full autonomous navigation if desired. People and face tracking can be used for natural interactions using OpenCV.
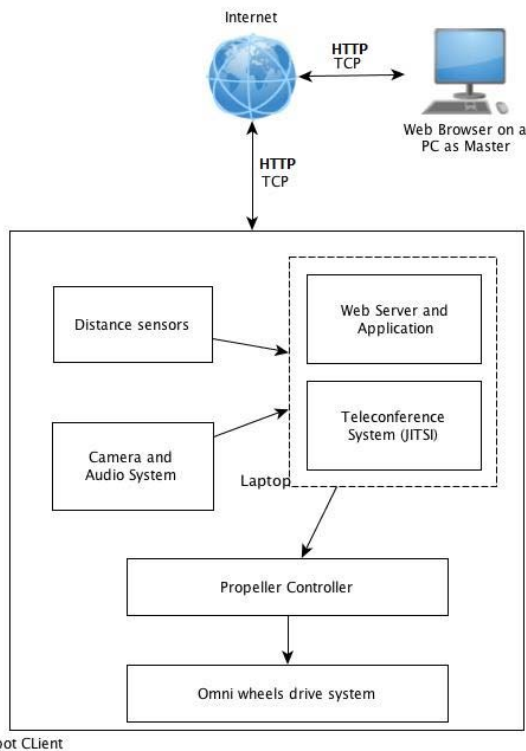

Fig. 2 Interconnecting Robot Client to Master through Internet

Interconnecting Master PC to client robot through Internet shown in Fig. 2. To increase mobility of the robot, Ethernet WiFi will be employed and HTTP over TCP is the connection protocol to control the robot. We develop web application using ASP .Net and IIS Web server for controlling the robot under Web.

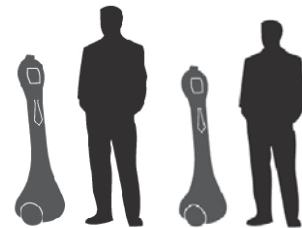The model of manager/supervisor to staff shown in Fig. 3:

Fig. 3 Manager/Supervisor have the ability to teleconference /inspection with many person.

C. Softwares

For this research we are using Openfire, Jingle Nodes and Jitsi for video conference. Openfire is a real time collaboration (RTC) that use XMPP (also called Jabber) as a protocol for instant messaging [5]. Jingle Nodes is an XMPP Extension that enable users to share and discover P2P Media Relays that can be used to enable Voice and Video Chat [6]. JITSI is an audio/video and chat communicator that supports XMPP/Jabber protocols [6]. Openfire and Jingle Nodes are used in server side and JITSI as client in this research. Jingle Nodes is using The Real Time Transport Protocol (RTP).

RTP provides end-to-end network transport functions suitable for applications transmitting real-time data, such as audio, video or simulation data, over multicast or unicast network services. RTP located on application layer in TCP/IP model and built on UDP protocol. The data transport of the protocol is augmented by a control protocol (RTCP) to allow monitoring of the data delivery in a manner scalable to large multicast networks, and to provide minimal control and identification functionality[9]. There are two use RTP scenarios as mentioned in [9] and related to our research. First scenario is simple multicast audio conference and second scenario is audio and video conference. One port is used for audio data, and the other is used for control (RTCP) packets for first scenario and the address and port information is distributed to the intended participants. If both audio and

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video media are used in a conference as second scenario, they are transmitted as separate RTP sessions. That is, separate RTP and RTCP packets are transmitted for each medium using two different UDP port pairs and/or multicast addresses. There is no direct coupling at the RTP level between the audio and video sessions, except that a user participating in both sessions should use the same distinguished (canonical) name in the RTCP packets for both so that the sessions can be associated [9].

III. EXPERIMENTAL RESULTS

Experiments of intelligent telepresence robot have been tested for navigating the robot to the staff in our office as shown in Fig. 4. Face tracking and recognition based on eigenspaces with 3 images per person used and databases for the images have been developed[8]. We also implement the Kalman filtering for distance measurement using stereo vision [10]. Based on the experiment, the system run very well with the capability to avoid obstacles and people and face tracking.
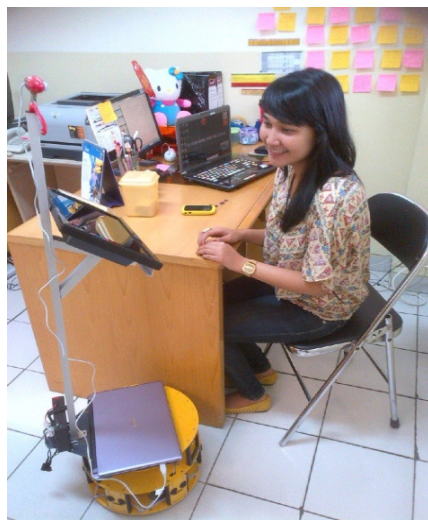

Fig. 4 Teleconference with a client based on Nexus Omni directional robot and OpenCV

Robot controlled using web Application that owned by each robot as shown in Fig. 5 below:
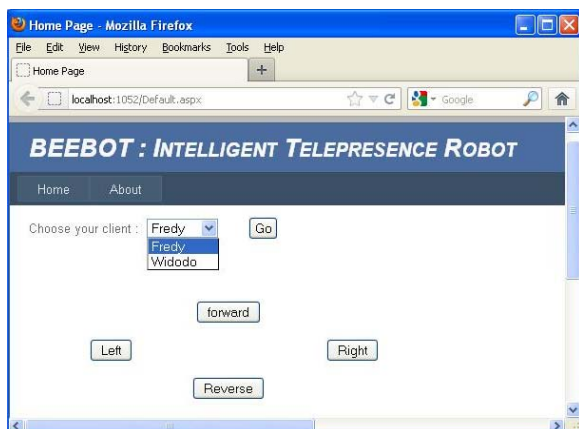

Fig. 5 Web application for choosing a client and direct a robot to a specified person

As shown in Fig. 5, master computer connect to the robot using port 1052 and HTTP protocol. Web browser will be used for controlling the robot. In Fig. 5 depicted four buttons that represent how the robot will move. The forward button will move the robot forward and the reverse button will reverse the robot. Another buttons are left and right which move the robot to the left and the latter will move to the right. The web application will send control data using the POST method and processing the command with a CGI script at the robot side [8]. With the high speed internet connection 1 Mbps, the result of video conferencing enough smooth, as shown in Fig. 6.
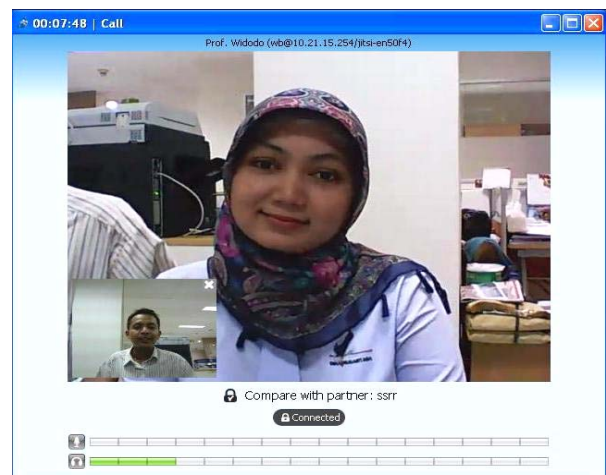

Fig. 6 JITSI as teleconference software used for telepresence robot

IV. CONCLUSION

The intelligent telepresence robot with multi-client capability is running well with fast movement using omni wheel drive. Stereo vision and fuzzy type-2 is potential for robot's navigation. Our proposed model potentially used by manager/supervisor at office /factory environment. Furthermore, we will develop autonomous navigation to a chosen location (e.g. production area) using stereo vision.

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