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Communication system for cooperative mobile robots — implementation of communication among soccer robots

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We regard communication as the essential tool to realize cooperation in a multiple robotic system. Generally, it is necessary for a communication system to reliably transmit messages (e.g. the TCP/IP). However, we consider that real-time message exchange is more important than the reliability in cooperation among multiple mobile robots. Since every robot cooperates mutually in a dynamic environment, delayed messaging or information is not available.

In order to achieve real-time communication for cooperation in a dynamic environment, we adopted a wireless LAN and developed a communication system on the UDP/IP. By using the UDP, data packets, exchanging messages, are sometimes lost in a noisy environment for the wireless LAN. The communication system retries to send a message according to the situations in which packets are lost. The serial number of sending a message, the counting value of receiving a message and not receiving message, the value of retry for sending, and the delay time for the retry are included to the exchange of messages from all of the robots. The counting value of not receiving a message is calculated from the serial number of sending a message and the counting value of receiving message from the other robots. Every robot can adjust a suitable value of retry for sending according tothe the receiving conditions.

Figure 1 shows the soccer robot system consisting of three mobile robots and a PC. Each robot and the PC are equipped with the developed communication system with the wireless LAN. The PC monitors a condition of communication by this system. In the RoboCup-98 in Paris, we have achieved communication-base team plays such as a pass-play between two

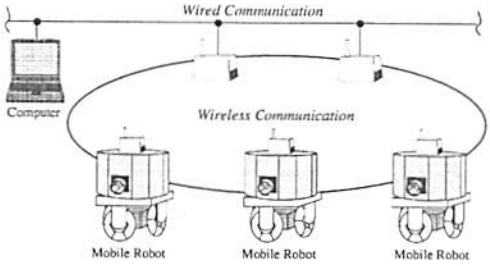

Figure 1. Soccer robot system.

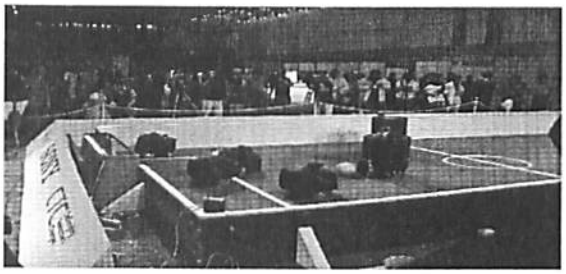

Figure 2. View of the soccer game played by mobile robots. The two robot on the right side are the communication-base cooperative robots and the four robots of the left side are opposing team.

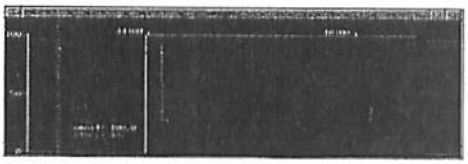

Figure 3. Monitoring of communication.

Time	to	from	control	type	message
48:00	*	smr2	9 108 219 2 100 5	ROBOCUP	PASS 4
48:00	*	smr2	10 108 219 2 100 5	ROBOCUP	PASS 4
48:00	omni4	smr2	11 109 219 2 100 5	ROBOCUP	PASS_OK 4
48:00	smr2	omni4	159 54 123 2 100 5	ROBOCUP	RECEIVE 4
48:00	omni4	smr2	12 109 219 2 100 5	ROBOCUP	PASS_OK 4
48:00	smr2	omni4	161 55 124 2 100 5	ROBOCUP	PASS_ACK 4
48:00	*	smr2	13 111 219 2 100 5	ROBOCUP	CONTROLLED
48:01	smr2	omni4	162 55 124 2 100 5	ROBOCUP	PASS_ACK 4
48:01	*	smr2	14 111 219 2 100 5	ROBOCUP	CONTROLLED

Figure 4. Communication record.

mobile robots (see Fig. 2) [1]. Figure 3 shows the communication monitoring on the PC. The x- and y-axis indicate elapsed time and the receiving rate, respectively. In Fig. 2, a robot maintains approximately 100% of the receiving rate and the receiving rate of another robot increases to approximately 100% from approximately 40% after 48 min. Therefore all of the robots adjust the value of retry for sending by a factor of 2. A part of the communication record for 48 min is show in Fig. 4. In this record, 'PASS', 'PASS_OK' and 'PASS_ACK' are sent twice respectively. However, 'RECEIVE' is sent one time only, indicating that the message is lost.

In conclusion, we confirm that communication-base cooperation by multiple mobile robots was accomplished by communicating so far as it is possible, even when the condition of the wireless LAN is insufficient, by using the communication system.

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