ULTRASONIC COMMUNICATION BETWEEN MOBILE ROBOTIC AGENTS

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ABSTRACT

Communication between robotic agents requires synchronized transmitting and sensing of data in the real world environment. We employed pre-made ultrasonic rangefinding units to successfully send signals from a stationary base to a tethered mobile receiver in a benchtop demonstration. When initiated, a sensor unit emitted a 40 kHz signal. By setting the order and timing of the signal, the receiver unit could detect the base had sent a signal. Ultrasonic waves were reflected with a cone mounted above the base emitter, enabling the signal to be detected omnidirectionally with radius of up to 6.7 m in 19.5 msec.

INTRODUCTION

Audible sound occurs in the 0.020 to 20 kHz frequency range. Stoneflies naturally use vibratory communication in pulse sequences at 58 to 118 msec intervals to attract mates (Sandberg and Stewart, 2001). Simple sonar sensors with echo can be used to maintain safe distances from objects for robots to display intelligent behavior (Brooks, 1999; Nehmzow, 2000). We used similar methods to send and receive ultrasonic signals between a base and a mobile sensing unit.

MATERIALS AND METHODS

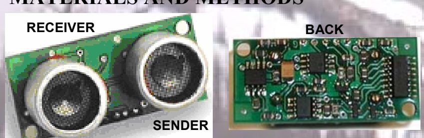

Fig. 1. Dual ultrasonic sensor units (SRF04) send ping signals and receive rangefinding echoes.

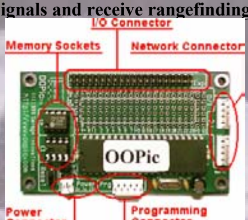

Fig. 2. Controller board OOPic II+ programmed with BASIC object code.

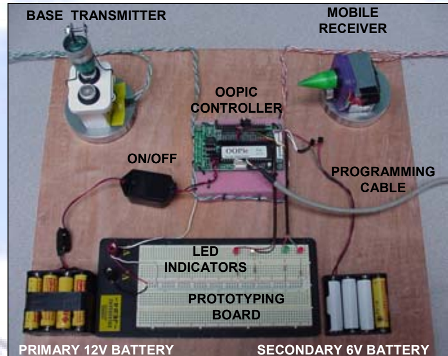

Fig. 3. Electronic sensor assembly. Two dual sensor units were integrated with an OOPic controller programmed to time the transmission of signals from base to receiver.

Fig. 4. SDT170 air leak detector used to troubleshoot, converted ultrasound to audible signals for synchronizing communications.

RESULTS AND DISCUSSION

Ultrasound travels about v=344 m/s in air at 20C. Sensor units determined distance by:

$$\text{Distance} = \tfrac{1}{2}\ v * t \qquad \text{eq. (1)}$$

with v, velocity (m/s), and t, time (sec).

Operation was altered by mounting the base unit to transmit normal to horizontal and adding a cone above the sender which reflected ultrasound waves outward in all directions (omnidirectional). The sender on the receiving unit was covered to assure only a signal from base was sensed. A green LED indicated the receiver was within range, and moving the mobile unit relative to the base confirmed the omnidirectional signal. Thus, the new calculation became:

$$\text{Distance} = v * t \qquad \text{eq. (2)}$$

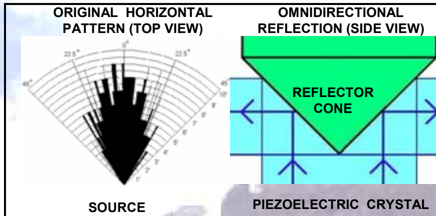

Fig. 5. Electronic activation of a piezoelectric crystal in the sensor unit emitted the original ping signal at 40 kHz, which was redirected to move omnidirectionally in the horizontal plane.

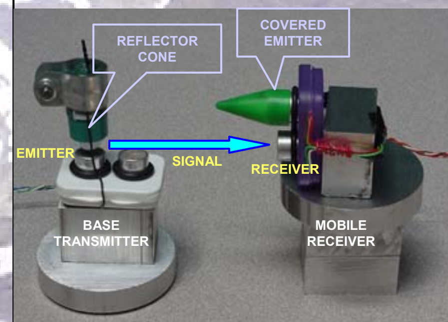

Fig. 6. A second piezoelectric crystal in the receiver resonated to the same natural frequency to confirm receipt of the signal from the base unit. Power was provided with +5V to both units.

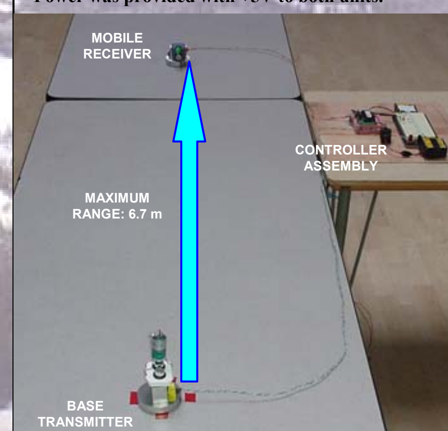

Fig. 7. A benchtop demonstration showed the receiver sensed the signal up to 6.7±0.1 m from the base omnidirectionally, traveled in 19.5 msec.

Lead batteries used as barriers showed the signal was interruptible within 0.3 m of either the base or the receiver unit. As the barriers were moved farther from the units, ultrasonic waves diffracted around the objects, enabling signal detection. As distance increased, wave amplitude attenuated below detection by the receiver. The signal was detectable in an arc similar to, but narrower than, that shown in Fig. 5.

Further Future Research

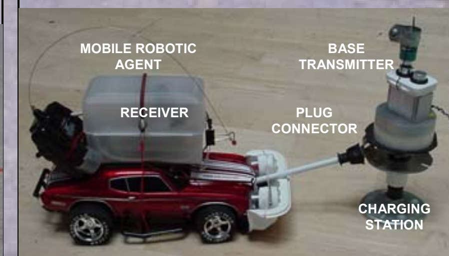

Fig. 8. Base signals should be detectable by a mobile robotic agent to locate a charging station, allowing the agent to recharge itself periodically.

CONCLUSION

A signal emitted omnidirectionally in a horizontal plane by a base transmitter was sensed by a tethered mobile receiver, confirming the signal to be propagated from a specific direction up to 6.7±0.1 m away, with elapsed time of about 19.5 msec.

References

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Nehmzow, U. 2000. Mobile Robotics: A Practical Introduction. Springer-Verlag: London.

Sandberg JB and Stewart KW. 2001. Drumming behavior and life history notes of a high-altitude Colorado population of the stonefly Isoperla Petersoni Needham & Christenson (Plecoptera : Perlodidae). Western North American Naturalist 61 (4): 445-451.

Sensor units/programming from: www.acroname.com www.oopic.com; www.sdtnorthamerica.com

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