A Khepera communication module supporting directed power-variable transmission

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Abstract. We present a prototype of an infrared communication module for the mini robot Khepera. Compared to other wireless communication modules, it features bi-directional transmission in eight sectors (directions) with variable transmission power. The maximum communication distance is 1 m at a data rate of 23.4 kbps. Our demonstration shows two Kheperas that establish a communication link. The transmission power can be adjusted and the received signal strength as well as the direction-of-arrival (DOA) of the incoming signal are shown.

1   Introduction

Communication is an important mean to enable the cooperation in a colony of mobile robots. Traditional communication devices for robots support omni-directional data transmission at a fixed transmission power, e.g. K-Team's radio turret for the mini robot Khepera. Savings in energy consumption and higher capacities, i.e. number of users per area, are possible if directed, power-variable transmission is employed. In this paper, we describe a communication module designed for the mini robot Khepera that allows bi-directional communication in eight sectors (directions) with per-sector adjustable transmission power. We employ the module for research on new communication protocols for mobile ad hoc networks, object localization and blinding avoidance for cars.

2   Approach

The communication module (fig. 1) consists of a transceiver board and a FPGA ciruit board. The transceiver board contains a multi-channel digital/analog converter that controls eight field effect transistors. The transistors control the current that excites the infrared diodes. Two diodes are connected in sequence with one transistor to illuminate one sector. The receiver part contains a analog/digital converter and a multiplexer that sample 16 infrared sensors in sequence. The signal processing is done in a field programmable gate array (FPGA). We have developed a dedicated digital circuit that converts data packets in light impulses by using a pulse position modulation (PPM), detects the synchronization preamble of incoming signals and
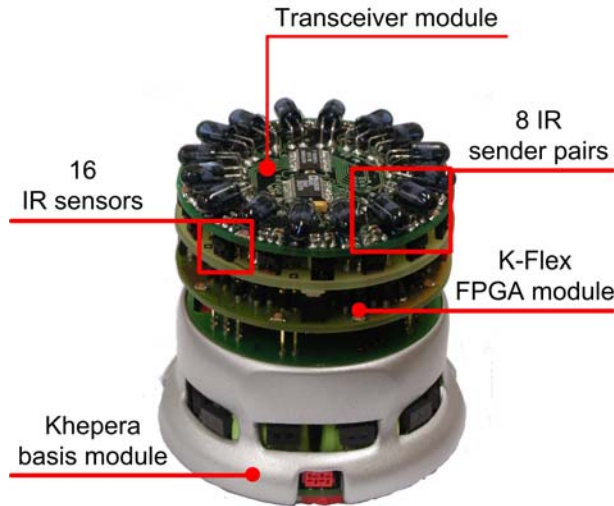
Figure 1. A Khepera II with the mounted infrared communication module

converts the detected light pulses back into a data packet. Our signal processing algorithm has the ability to detect signals while other incoming signals in adjacent sectors cause interferences. Additionally, it can estimate the direction-of-arrival (DOA) with an average error below $10°$. The algorithm has a low complexity such that it can be implemented with the limited resources available in a mini robot. Our chosen components and algorithm parameters allow bi-directional links up to one meter at a raw data rate of 23.4 kbps. The electrical power requirements are 90 mW for receiving and a maximum transmission power of $2.3 \mu W/_{Bit}$ for transmitting in one direction.

3   Demonstration

In our demonstration, we show two Khepera robots equipped with the described communication module. The robots transmit and receive light pulses and record the received signal strength distributed over the sensor array. The direction-of-arrival of the signal is also estimated. The transmission power per sector can be adjusted and the effects of non-uniform illumination and co-sector interferences can be observed by locating one robot at different locations in the transmission sector of the other robot. The prototypes are the result of the work presented in [1] that contains further details about the signal processing algorithm as well as results from simulations and experiments.

References

[1] M. Grünewald, U. Rückert, , C. Schindelhauer, and K. Volbert. Directed power-variable infrared communications for the mini robot Khepera. In *Proceedings of the 2nd International Symposium on Autonomous Minirobots for Research and Edutainment*, Brisbane, Australia, February 18-21 2003.