Sound of (something completely different like) Music
Audible Landmarks for Robotic Soccer

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Austrian Kangaroos
Vienna University of Technology
University of Applied Sciences Technikum Vienna

I. Motivation

One long term goal of RoboCup is to raise robotic soccer to a human like level in terms of quality and robustness. Therefore, several challenges exist that have to be overcome. To name two major challenges, one is localization, not only self localization but also team mate localization, another one is that of robust communication. Our contribution for this year's SPL Open Challenge tackles both. We think that state of the art SPL soccer players are not complete in terms of organs of perception and hence introduced acuesthesia for our robots. By granting the ability to hear their environment and their team mates we add another missing link to competitive human like soccer skills. In a first step, we cover a player's ability to sense the relative position to a team mate by audible indicators given by the team mate. In a human soccer match this scenario can be projected onto a pass receiver shouting "I am here! Pass now!". In a second step (that is not part of this presentation) we add information similar to the one that is currently broadcasted via WLAN to the audible landmark to overcome unreliable WLAN connectivity.

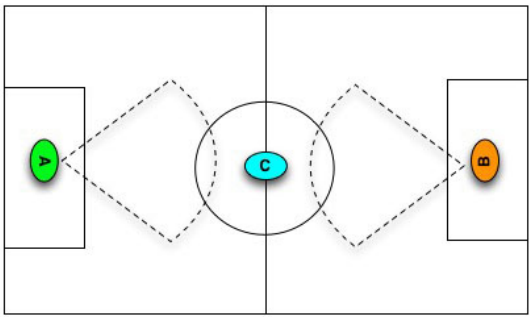

Figure 1: Setup for Audible Landmark Detection

II. Methodology

To determine the relative position of two players on a soccer field over air-channel, one sender is required that emits a well-defined signal which subsequently is received by another robot. Utilizing multiple spacial distinct microphones a direction of the sender relative to the receiver can be estimated. For our implementation the signal emitted by the sender is a binary phase-shift keying (BPSK) encoded bit-stream that represents a unique pattern. This BPSK signal is being decoded at the receiver's side. Matching the perceived sound using the interaural time difference (ITD) results in an adequate estimation of the direction to the senders current position. By utilizing the interaural level difference (ILD) as a cue localization results can be improved if required in future applications. By using BPSK as modulation another advantage can be gained nearly for free: a payload of arbitrary information can be carried by the audible landmark signal.

III. Demonstration

In our presentation we will demonstrate our robots' ability to sense directions of audible landmarks by using a setup as shown in Figure 1. NAO C, our test subject, is located at the center of the soccer field facing at the intersection of the mid-line and the out-line. The robot's visual as much as its ultrasonic sub system is disabled so the robot must completely focus on acuesthesia. Two team mates, NAO A and NAO B, are positioned within each half of the soccer field facing our test subject. In addition, the experiment requires a volunteer from the audience. Given this setup the experiment is implemented via the following procedure: The volunteer may choose either robot A or robot B. The chosen NAO now emits the audible landmark, which is perceived by the test subject. Utilizing our direction indication algorithm the relative position of the audible landmark is calculated. To confirm its perception test subject NAO C will point towards the team mate that "called" for attention. The procedure can be repeated several times in order to prove functional.

IV. Results and Expectations

Our work shows that audible sensing can successfully be integrated into a soccer playing SPL robot. By introducing acuesthesia we enable another robust tool for self-localization as much as team-mate localization. Upcoming work will cover data exchange without WLAN for SPL players in order to overcome typical problems of team communication at soccer tournaments.