Indoor localization based on oscillating magnetic fields

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Indoor Localization is still an issue of intense research. Signal attenuation, multi-path effects or signal shielding falsify the used measurement signal and result in inaccuracies of the position estimation. The effects arise due to the dynamic environment, persons walk around, equipment start and stop and therefore emit electro magnetic fields, the environment is changed by opening doors or moving furniture.

One possible solution for these effects are magnetic fields. Magnetic fields are hardly influenced by humans or furniture. Also walls do not hinder the physical measurement basis. This effect has been proven in [1] where the measured raw signal is changed within a boundary of 3 percent when ferromagnetic materials are placed in the magnetic field. The signal is only influenced in a small area around the distortion as the magnetic field lines are locally bent by the ferro magnetic material, the overall shape of the magnetic field stays stable.

Our system consists of two parts, multiple magnetic field emitters (base stations, beacon emitters) and wearable receivers. A transmitter covers an area of $60m^2$ and is RF synchronized. To support localization for a $300m^2$ area 8 to 10 transmitters are necessary. Three perpendicular transmitter axes sequentially emit the fields. The generated oscillating magnetic fields are measured by wearable receivers which process the measurements and transmit the raw data to a processing computer. This computer uses a magnetic field model and transforms the measurements to position information.
As the setup of our system in the last competition was complex and required many ethernet connections to synchronize the transmitters, we switched from ethernet to Zigbee based triggering. The wearable receiver periodically sends a trigger message to the transmitter which then starts its measurement cycle. The transmitters therefore only require a power supply.

We also reworked the magnetic field model, which allows

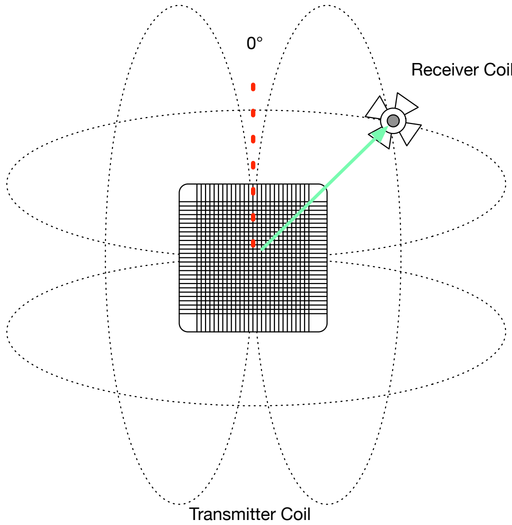

Figure 1: The intersection of the estimated field lines estimated in the measurement reduces the position of the receiver to these intersections.

a limitation of the possible position of the receiver to 8 points around a single transmitter coil due to the the 3 axes transmitter coil setup. Combining measurements to multiple transmitters results in intersection of possible position sets which result in a single position. To overcome noncovered areas we added an inertial measurement unit. The PDR based algorithm uses the acceleration, gyroscope and earth magnetic information to detect steps and the movement direction. A particle filter fuses the PDR information and the magnetic field position estimation.

1. REFERENCES

[1] G. Pirkl and P. Lukowicz. Robust, low cost indoor positioning using magnetic resonant coupling. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, pages 431–440. ACM, 2012.