Pose tracking of magnetic objects

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Magnetometer measurement models

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   Assume that the magnetometer (almost) only measures the local (earth) magnetic field.
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Magnetic mapping

Build a map of the indoor magnetic field. This map can be used for localization.

We have used Bayesian models (Gaussian processes) to model such fields with good results.
Magnetometer measurement models

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2. **My use:** Magnetometer(s) to provide **position and orientation** information.
   
   ▶ **Magnetic mapping:** Build a map of the (indoor) magnetic field.
   
   ▶ **Magnetic tracking:** Measure the position and orientation of a known magnetic source.
Sensor setup

We use a sensor network with four three-axis magnetometers to determine the position and orientation of a magnet.
Magnetic tracking

Advantages

▶ Cheap sensors
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Magnetic tracking

Advantages

- Cheap sensors
- Small sensors
- Low energy consumption
- No weather dependency
- Passive unit, requires no batteries
Mathematical model - dipole field

The magnetic field can be described with a dipole field.

\[
B(r) = \frac{\mu_0}{4\pi \|r\|^{5}} \left( 3r \cdot r^T - \|r\|^2 I_3 \right) m
\]

\[
= C(r)
\]

\[
m \triangleq \frac{1}{2} \int r' \times J(r') d^3r'
\]
Sensor model - single dipole

The measurements can be described with a state-space model

\[ x_{k+1} = F_k x_k + G_k w_k, \quad w_k \sim \mathcal{N}(0, Q), \]
\[ y_{k,j} = h_j(x_k) + e_k, \quad e_k \sim \mathcal{N}(0, R) \]

Point target sensor model (one dipole)

\[ h_j(x_k) = C(r_k - \theta_j)m_k, \quad x_k = \begin{bmatrix} r_k^T & v_k^T & m_k^T & \omega_k^T \end{bmatrix}^T \]

\[ C(r) = \frac{\mu_0}{4\pi\|r\|^5} (3rr^T - \|r\|^2 I_3), \]

Measurement from a sensor network of magnetometers positioned at \( \{\theta_j\}_{j=1}^J \).

Degrees of freedom

- 3D position
- 2D orientation
Experiment 1
Experiment 2 - setup
Experiment 2 - results - position

Experiment - results - orientation

Black: Ground truth orientation. Color: Estimated orientation
Application 1: 3D painting book
Application 2: Digital water colors
Application 3: Digital table hockey
Application 4: Digital pathology
In February 2017 a company was started around this technology.

In total seven people are involved in the company on part-time.

Collaborations with both gaming companies and industrial partners.
Thank you!