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Pose tracking of magnetic objects

Niklas Wahlström

Department of Information Technology, Uppsala University, Sweden

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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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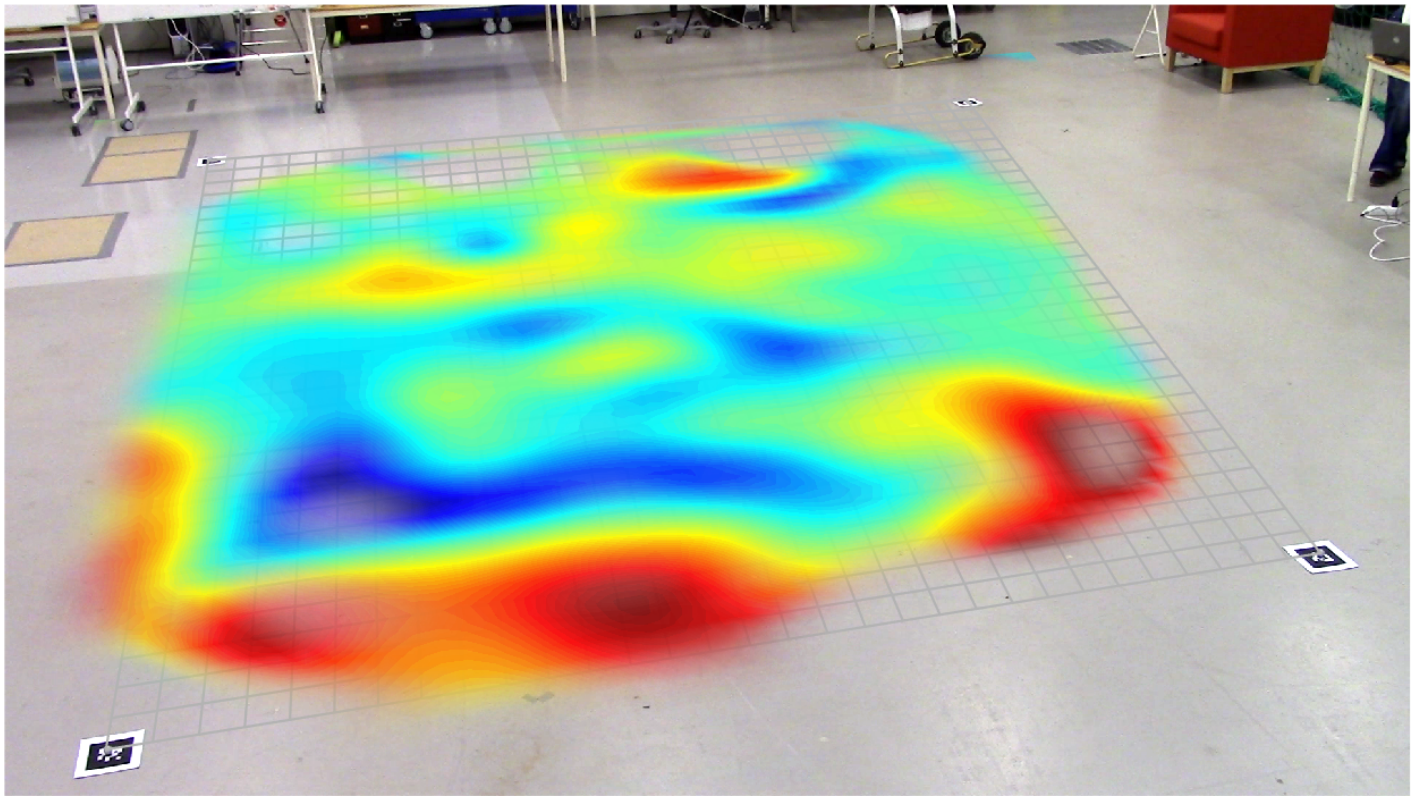
Magnetic mapping

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

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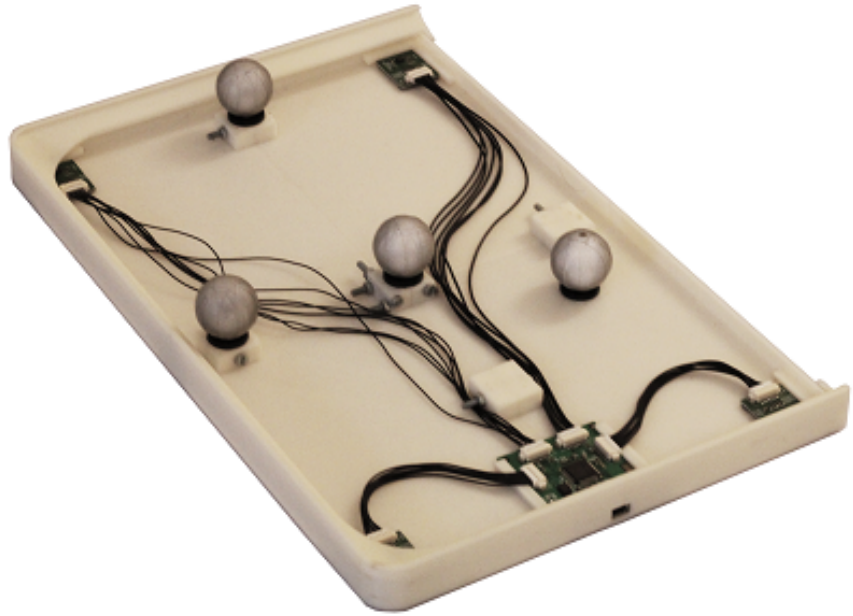
   Assume that the magnetometer (almost) only measures the local (earth) magnetic field.

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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- Small sensors

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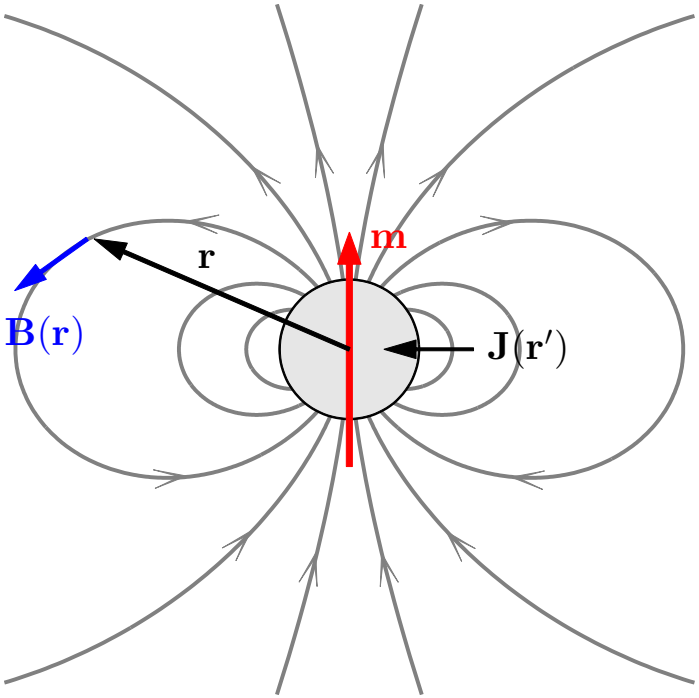
Advantages

- 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.



$$\mathbf{B}(\mathbf{r}) = \underbrace{\frac{\mu_0}{4\pi\|\mathbf{r}\|^5}\left(3\mathbf{r}\cdot\mathbf{r}^{\mathsf{T}} - \|\mathbf{r}\|^2 I_3\right)}_{=C(\mathbf{r})}\mathbf{m}$$

$$\mathbf{m} \triangleq \frac{1}{2}\int \mathbf{r}' \times \mathbf{J}(\mathbf{r}')d^3r'$$

Sensor model - single dipole

The measurements can be described with a state-space model

$$\mathbf{x}_{k+1} = F_k \mathbf{x}_k + G_k \mathbf{w}_k, \qquad \mathbf{w}_k \sim \mathcal{N}(\mathbf{0}, Q),$$
$$\mathbf{y}_{k,j} = \mathbf{h}_j(\mathbf{x}_k) + \mathbf{e}_k, \qquad \mathbf{e}_k \sim \mathcal{N}(\mathbf{0}, R)$$

Point target sensor model (one dipole)

$$\mathbf{h}_j(\mathbf{x}_k) = C(\mathbf{r}_k - \boldsymbol{\theta}_j)\mathbf{m}_k, \qquad \mathbf{x}_k = [\mathbf{r}_k^\mathsf{T} \quad \mathbf{v}_k^\mathsf{T} \quad \mathbf{m}_k^\mathsf{T} \quad \boldsymbol{\omega}_k^\mathsf{T}]^\mathsf{T}$$
$$C(\mathbf{r}) = \frac{\mu_0}{4\pi\|\mathbf{r}\|^5}(3\mathbf{r}\mathbf{r}^\mathsf{T} - \|\mathbf{r}\|^2 I_3),$$

Measurement from a sensor network of magnetometers positioned at $\{\boldsymbol{\theta}_j\}_{j=1}^J$.

Degrees of freedom

- 3D position
- 2D orientation

niklas.wahlstrom@it.uu.se

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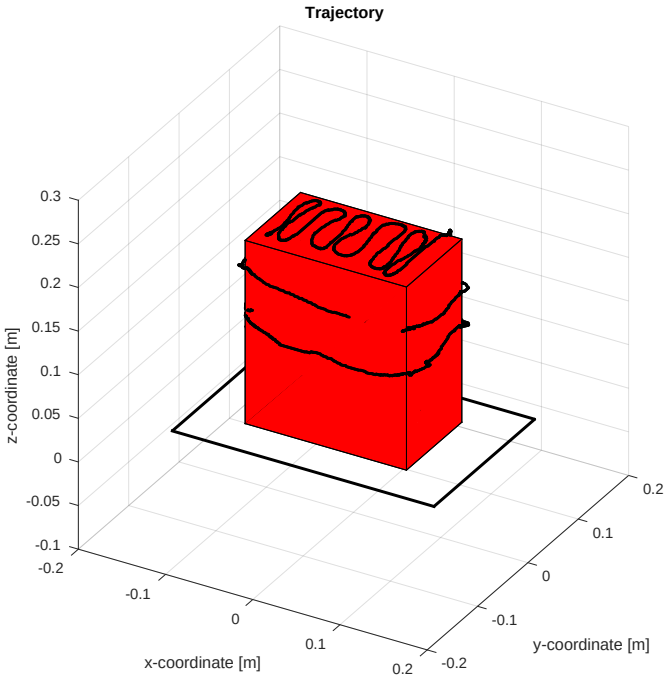
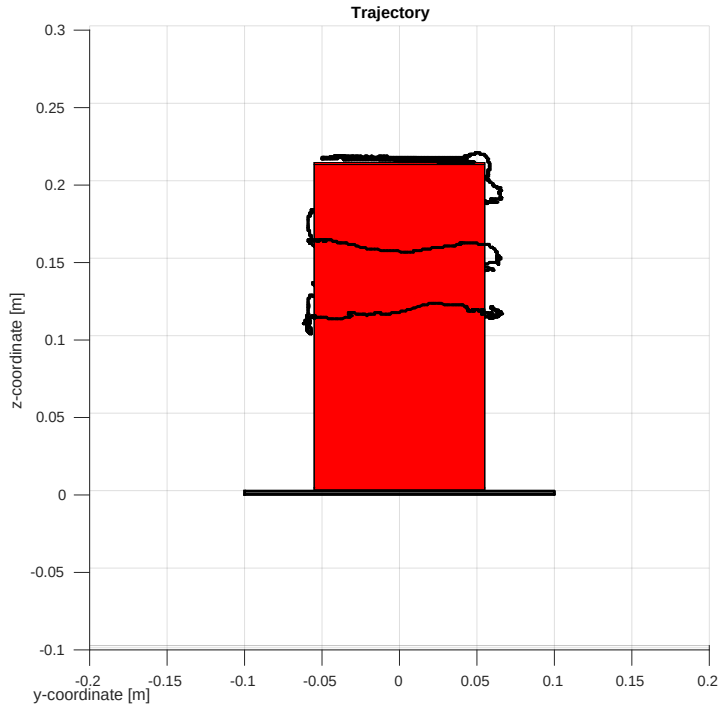
Experiment 1





accuracy is

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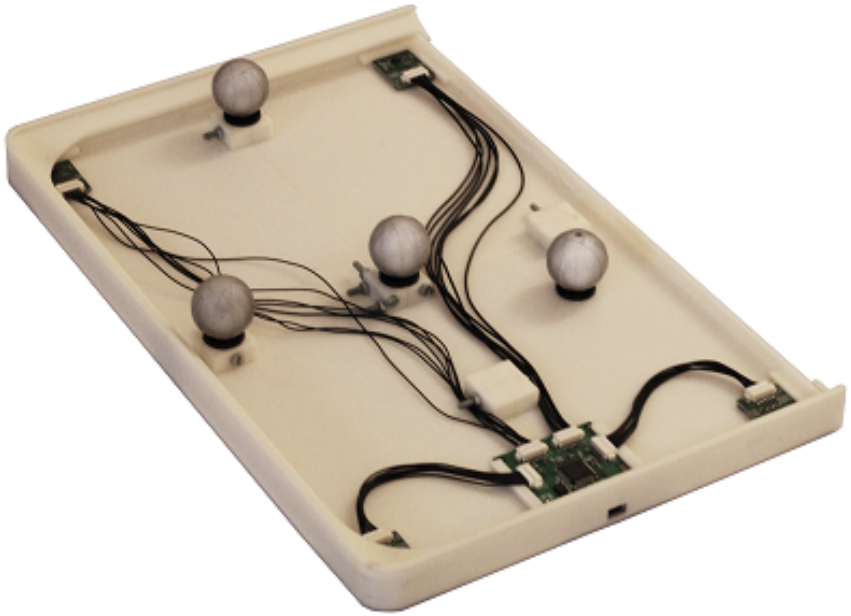
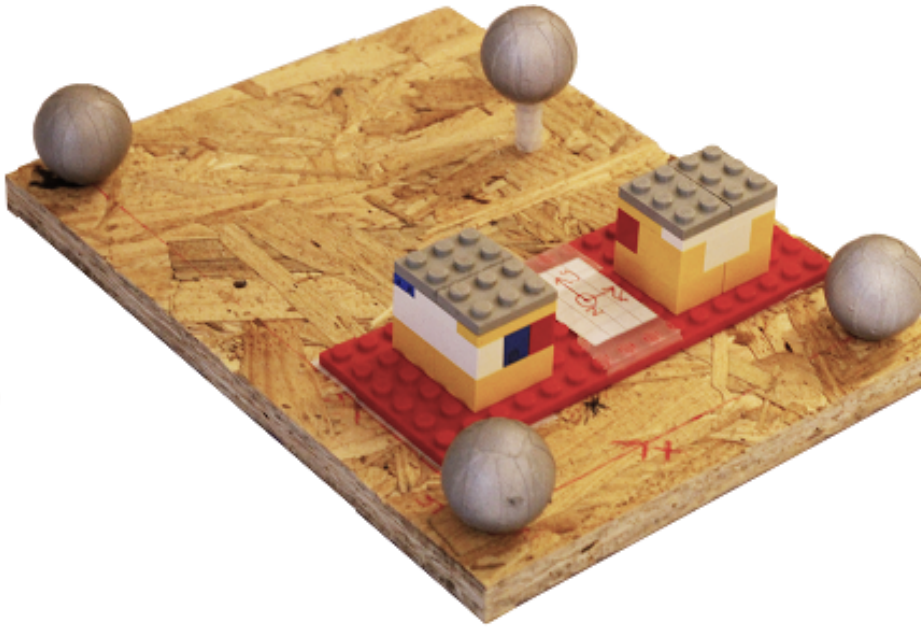
Experiment 2 - setup





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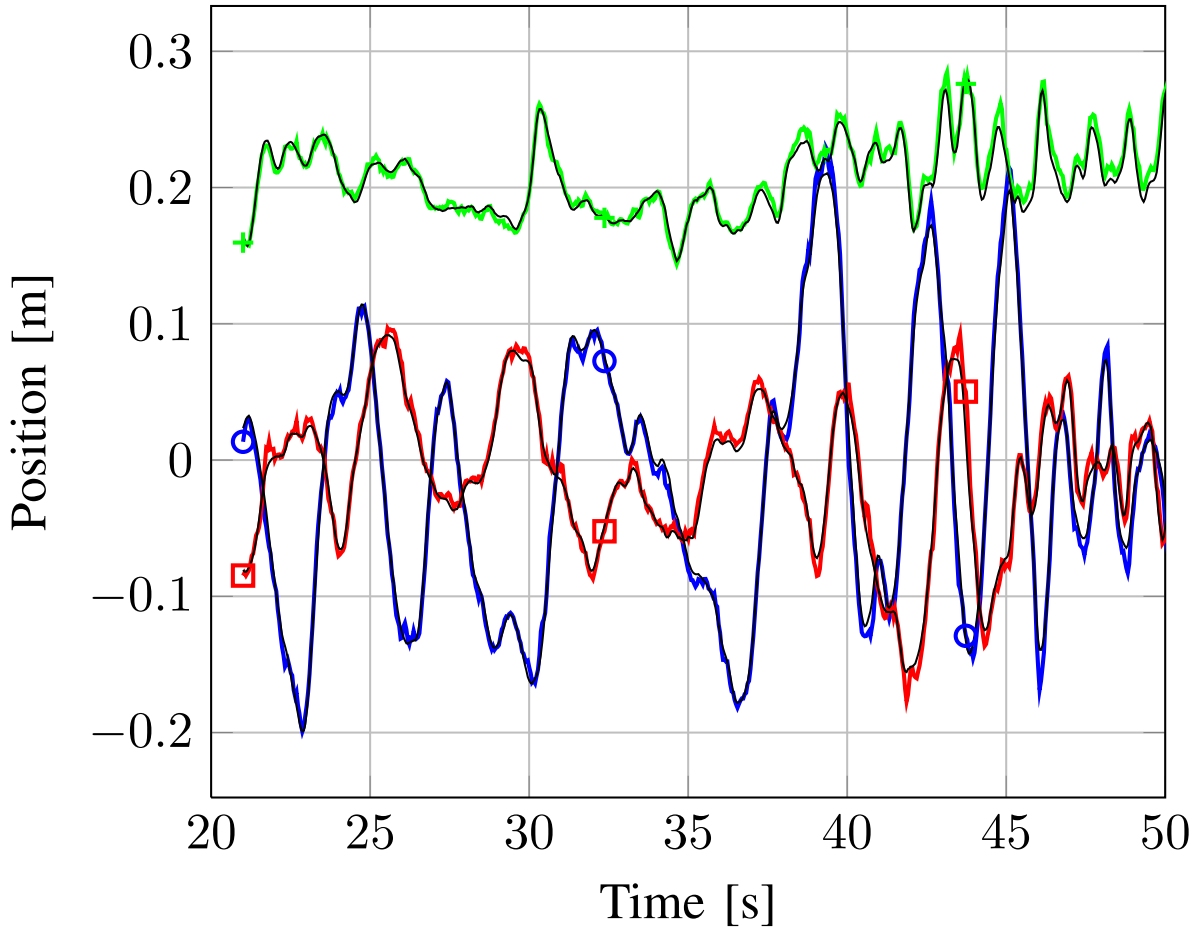
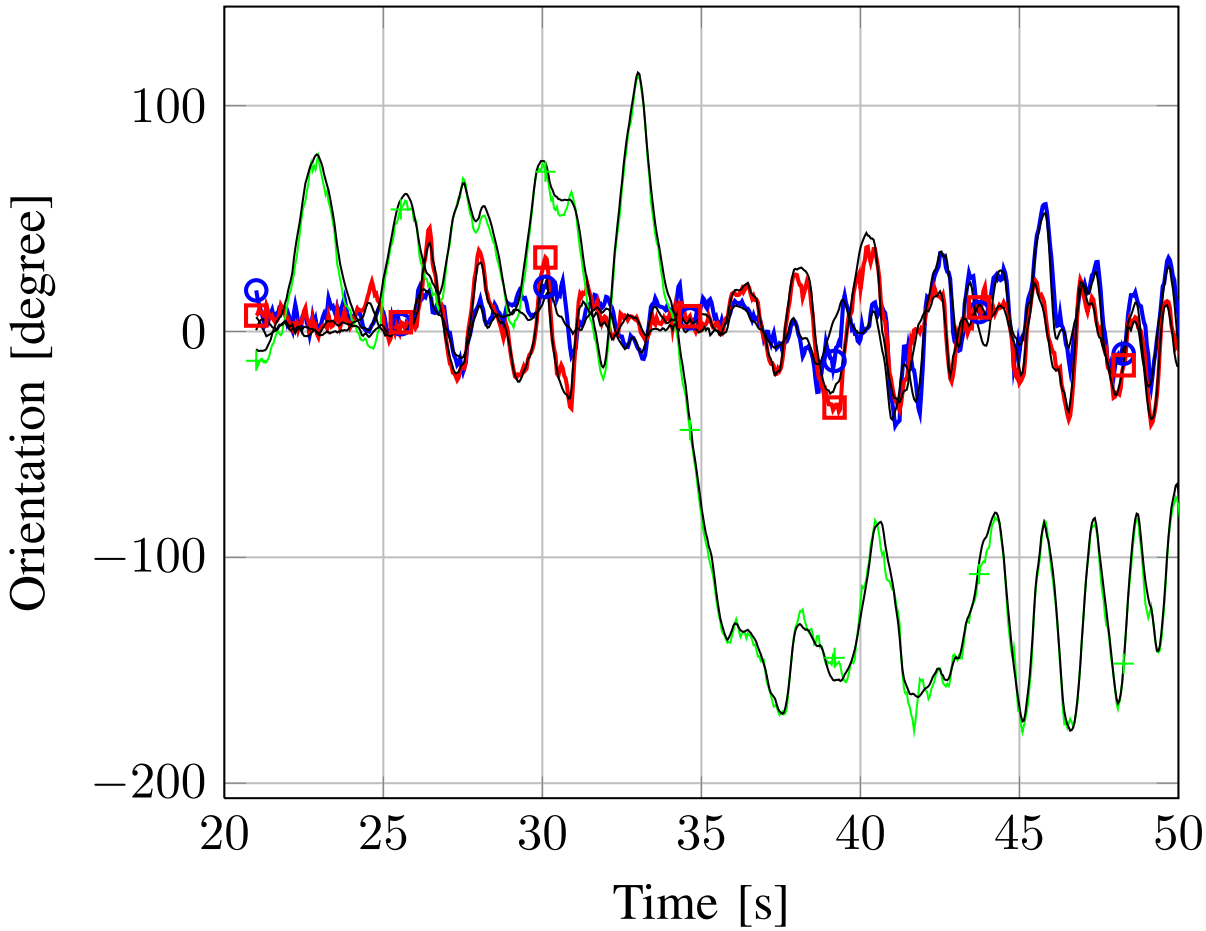
Experiment 2 - results - position



Black: Ground truth position. Color: Estimated position

Experiment - results - orientation



Black: Ground truth orientation. Color: Estimated orientation

Application 1: 3D painting book

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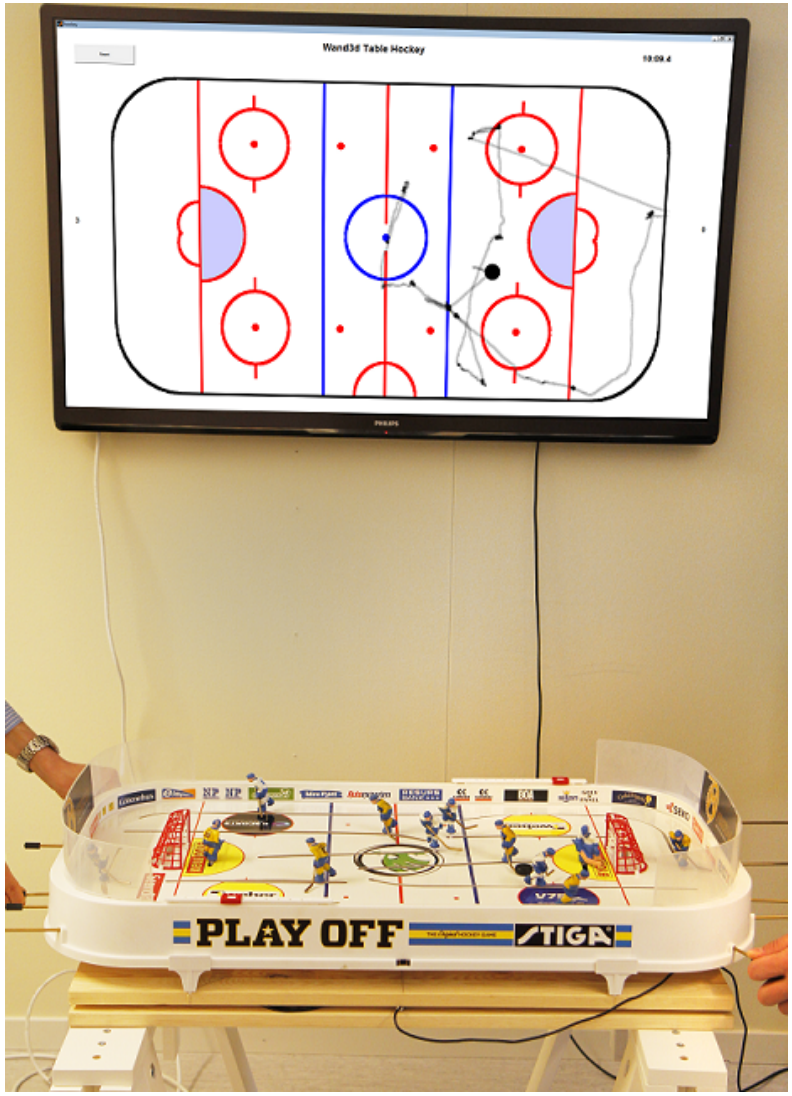
Application 2: Digital water colors

Application 3: Digital table hockey



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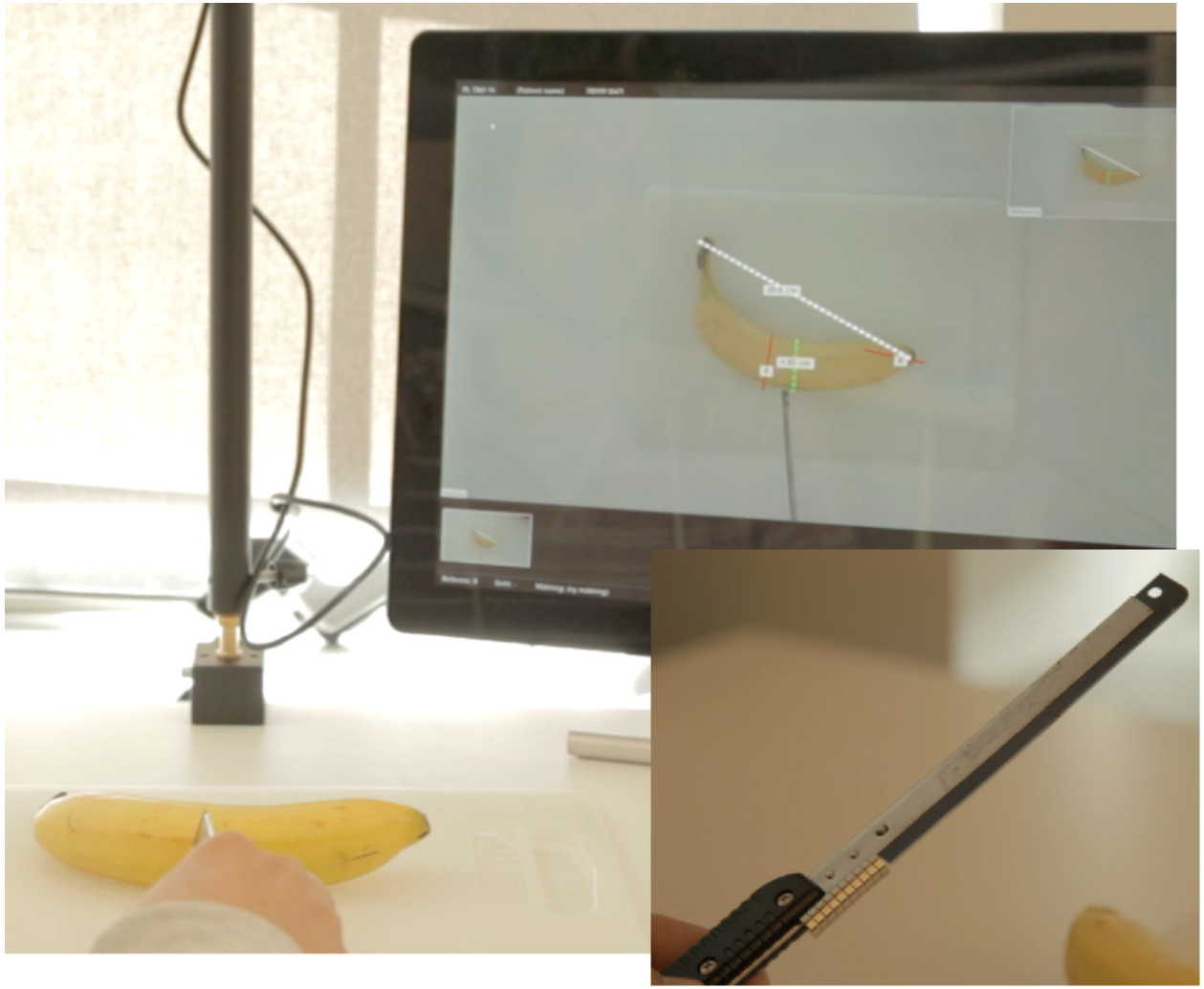
Application 4: Digital pathology



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Stylaero AB

- 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.

STYLAERO

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Thank you!

niklas.wahlstrom@it.uu.se