# Tracking of Dolphins in a Basin Using a Constrained Motion Model

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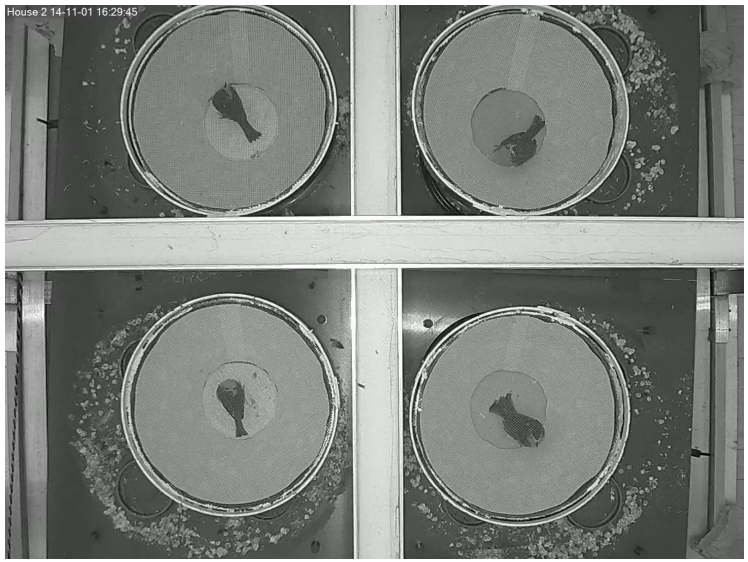
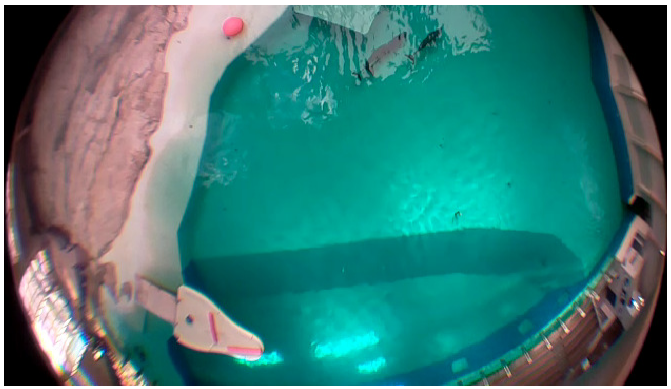
# Animal Behaviour and Population Studies

- Behaviour studies for research
- Population monitoring for preservation
- Manual solutions



# Problem Description

- Dolphinarium at Kolmården Wildlife Park
- Sonar transponders in basin
- Manual work thus far
- Trajectories as results



1 Background
Animal Studies
Problem Description
2 Solution
Pipelined Solution
Foreground Segmentation
Constrained Motion Model
3 Results
Motion Model
Trajectory Extraction
4 Conclusions

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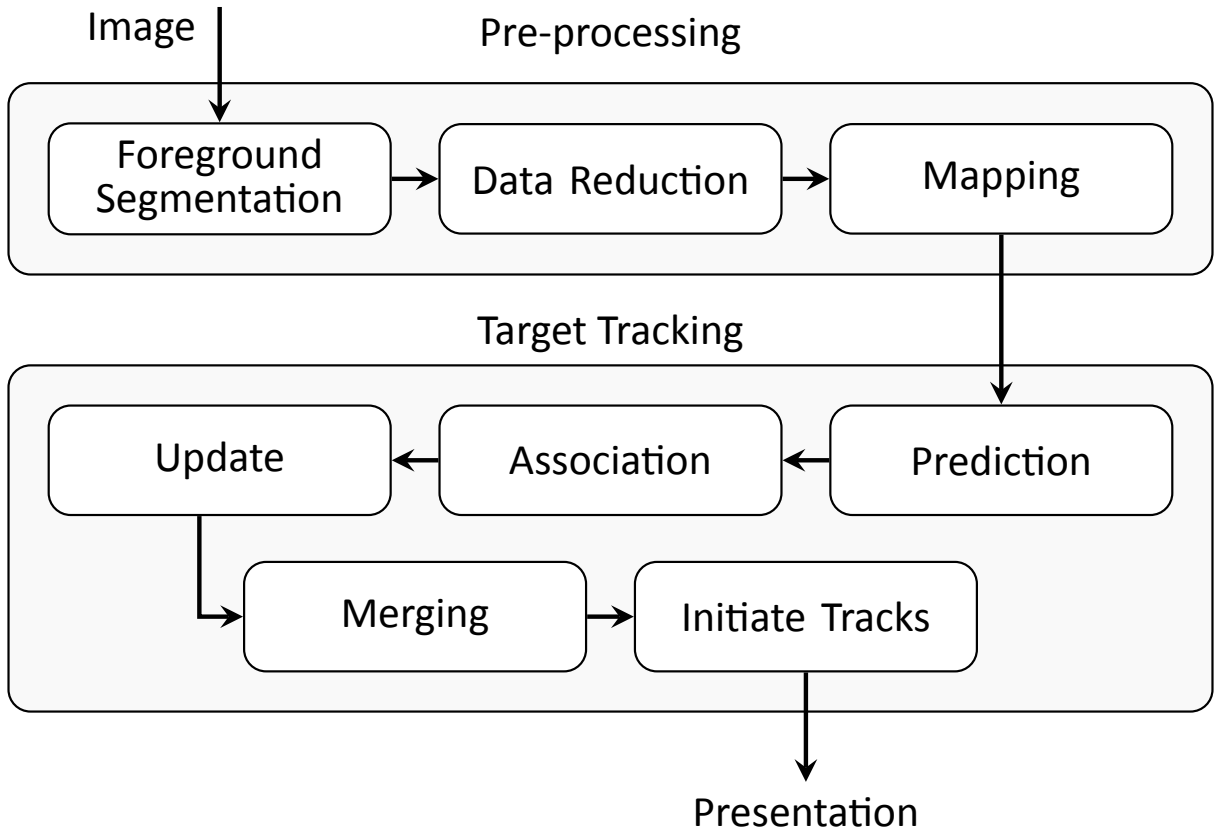
# Pipelined Solution



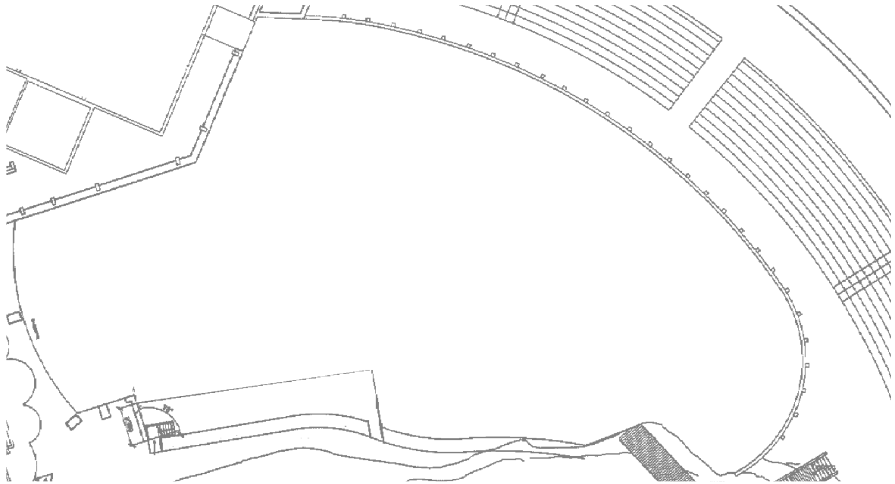
# Foreground Segmentation

- Reflections, shadows and changing light conditions
- Modeled as Gaussian-Mixture process per pixel estimated using the Expectation-Maximization algorithm
- Confidence measurement available

# Constraint Model

- Several occluded areas
- Inspired by potential fields
- Turn rate is predicted as

$$\omega(\mathbf{x}) = \int_{\mathbf{N}} \big(\alpha + \beta(\dot{\mathbf{p}}_{\perp} \cdot \mathbf{l}(\mathbf{n}))\big) w(\mathbf{x}, \mathbf{n})\, d\mathbf{n}$$



# Constraint Model

- The constrained region boundary is modeled as a polygon reducing the predicted turn rate to

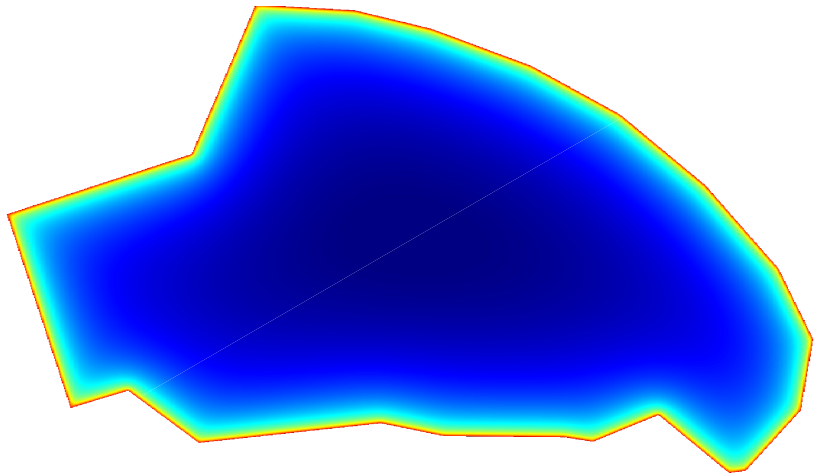
$$\omega(\mathbf{x}) = \sum_i \left(\alpha + \beta(\dot{\mathbf{p}}_\perp \cdot \mathbf{l}_i)\right) \int_{\mathbf{N}_i} w(\mathbf{x}, \mathbf{n})\, d\mathbf{n}$$

# Constraint Model

- The influence asserted by each point on the boundary is modeled as

$$w(\mathbf{x}, \mathbf{n}) = \frac{1}{\|\mathbf{p} - \mathbf{n}\|^2}$$

- Integration over the boundary $\mathbf{N}$ for each point



# Constrained Motion Model

- Coordinated turn motion model $\mathbf{f}\big(\mathbf{x}, \omega(\mathbf{x})\big)$ with the predicted turn rate
- The Jacobian of $\mathbf{f}\big(\mathbf{x}, \omega(\mathbf{x})\big)$ is computed as

$$\mathbf{F}\big(\mathbf{x}, \omega(\mathbf{x})\big) = \frac{\partial \mathbf{f}}{\partial \mathbf{x}}\big(\mathbf{x}, \omega(\mathbf{x})\big) + \frac{\partial \mathbf{f}}{\partial \omega}\big(\mathbf{x}, \omega(\mathbf{x})\big)\frac{\partial \omega(\mathbf{x})}{\partial \mathbf{x}}$$

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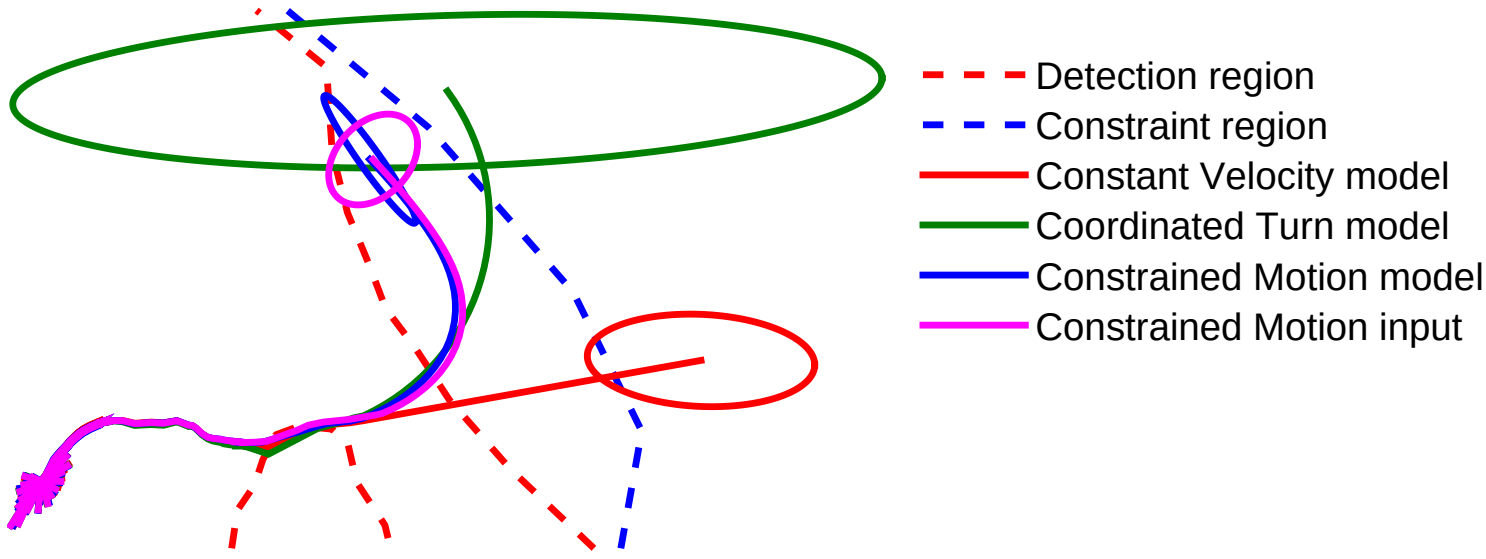
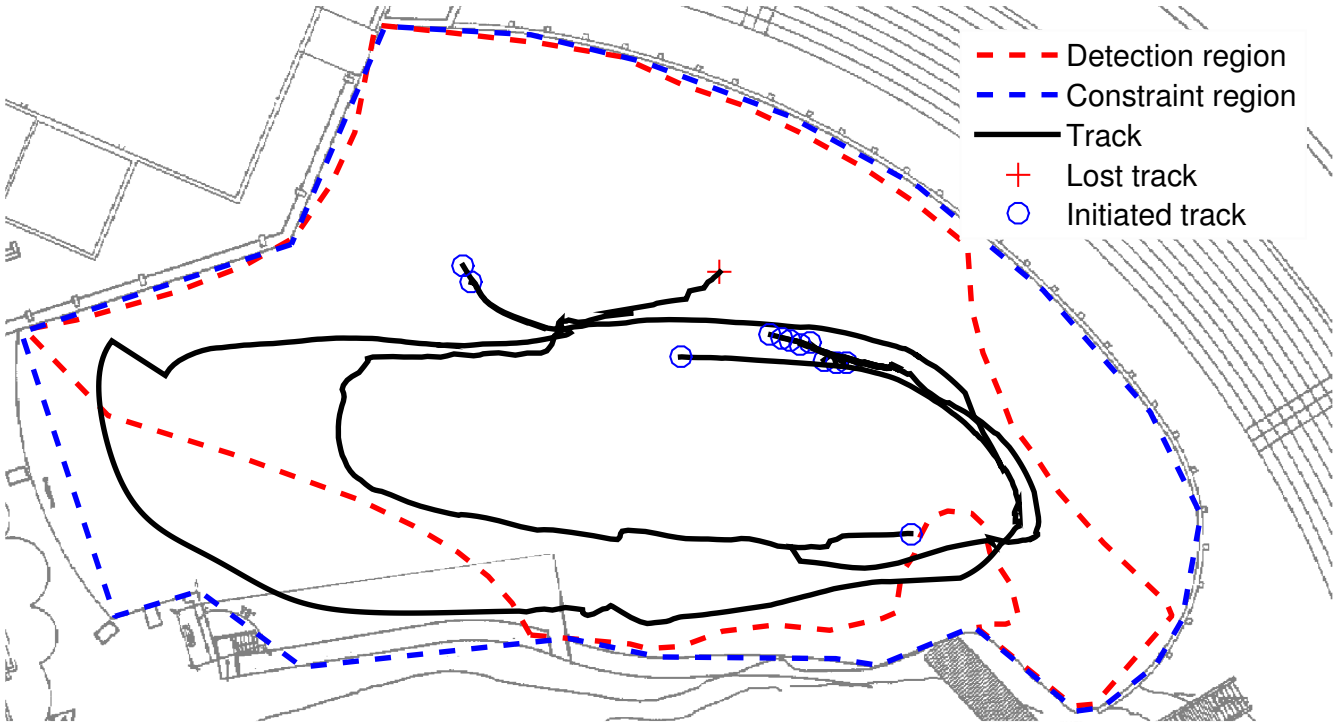
# Motion Model Comparison



# Trajectory Extraction Results



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# Conclusions

- Foreground segmentation is able to extract dolphins with sufficient accuracy despite poor light conditions
- A constrained motion model is proposed allowing predictions of dolphins in a constrained environment
- Occlusions from the camera are handled

# Future Work

- Use a state-of-the-art target tracking algorithm
- Feedback from target tracking framework to measurement pre-processing

# Thank you for listening!

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