science of intelligence

Scientific Networking Days
Research Unit 2
Project 35

Differentiable Interconnected Recursive Estimation as a Principle of Intelligence

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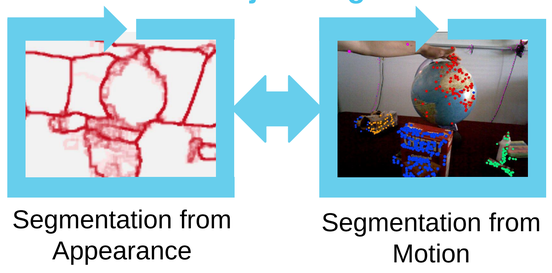
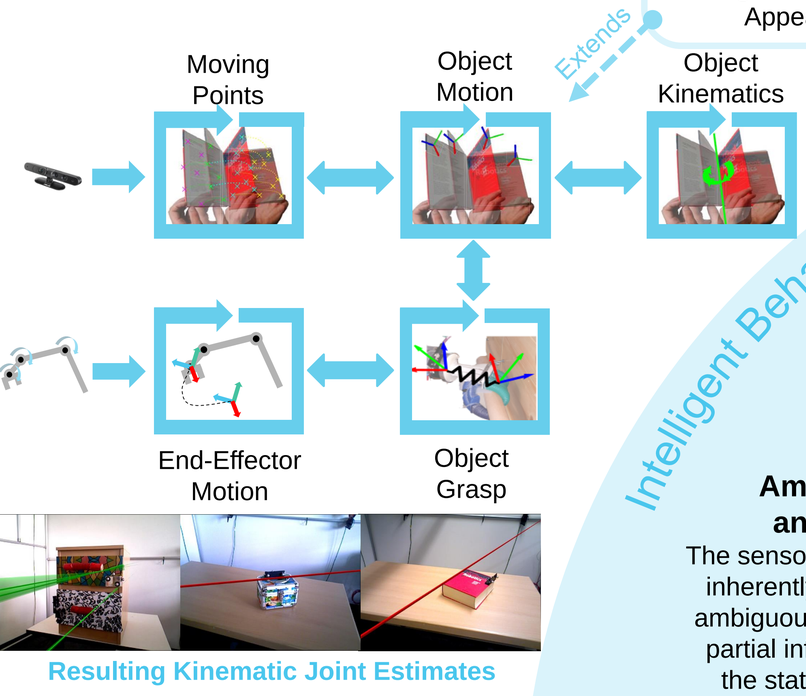
Building Robust Robotic Perception

We are investigating AICON as a candidate principle after its successes in building robotic perception systems as the one below. These systems are robust, because AICON focuses on the interactions between components which allows each estimator to take advantage of the information and encoded regularities within other parts of the system.

Multimodal Object Segmentation



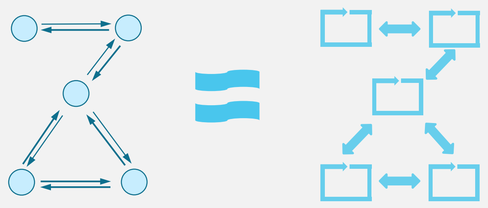
Extends



Resulting Kinematic Joint Estimates

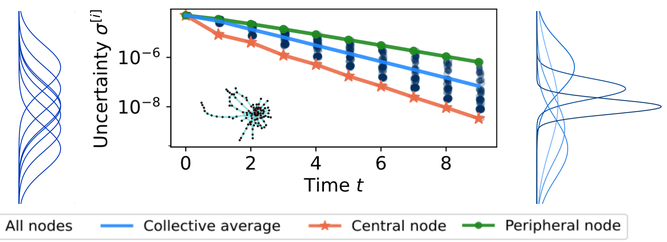
We also ***supervised two master theses*** further extending the above system: to better handle small objects (***collaboration with project 28***) or to initially identify possible interactions.

Modelling Collectives



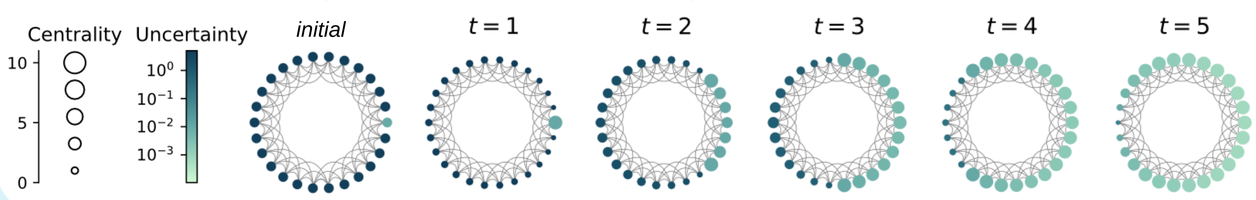
Collective Behavior emerges from agents interacting according to their current information. This is similar to how individual behavior arises from interacting components, as modeled with AICON. Thus, we can use AICON to model and study collective behavior.

Homogeneous Certainty, Heterogeneous Centrality



In a ***collaboration with project 27***, we use AICON to model collective opinion dynamics and thereby introduce a mechanism to estimate the uncertainty of each agent. This uncertainty influences the weights within the network and thus makes the weighting in the network adaptive.

Heterogeneous Certainty, Homogeneous Centrality



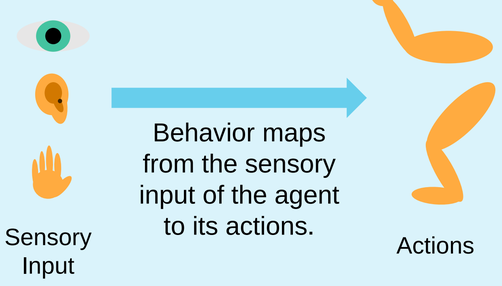
AICON – A Candidate Principle

Intelligent Behaviors as Information Processing Problems with Common Properties

High-Dimensionality
The space of sensor and action information is extremely high-dimensional and spans across time.

Weak-Decomposability
The mapping from sensors to actions is not easily decomposed into independent units but instead dependent on their interactions.

Ambiguities and Noise
The sensor-input is not only inherently noisy but also ambiguous, providing only partial information about the state of the world.



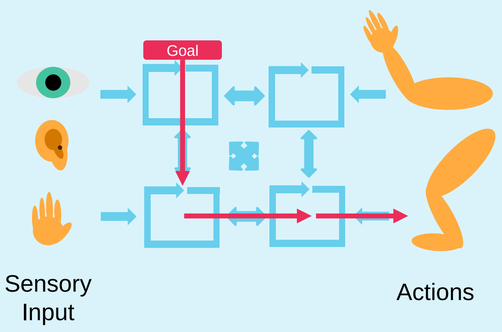
Behavior maps from the sensory input of the agent to its actions.

Dynamic and Stochastic Environment
The environment is constantly changing, often in unforeseen ways, requiring constant adaptation.

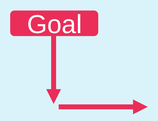
Recursive Estimators

Reduce ***High-Dimensionality*** by each solving a perceptual *sub*-problem.

Resolve ***Ambiguities and Noise*** by leveraging encoded regularities and temporal structure of the problem.



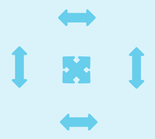
Immediately adapt actions according to feedback, making behavior robust in ***Dynamic and Stochastic Environments***.



Gradients

Consider perceptual and state changes in through multiple components and their interactions, reflecting ***Weak-Decomposability***.

Resolve ***Ambiguities and Noise*** by leveraging overlapping information of multiple subproblems and further encoded regularities.



Active Interconnections

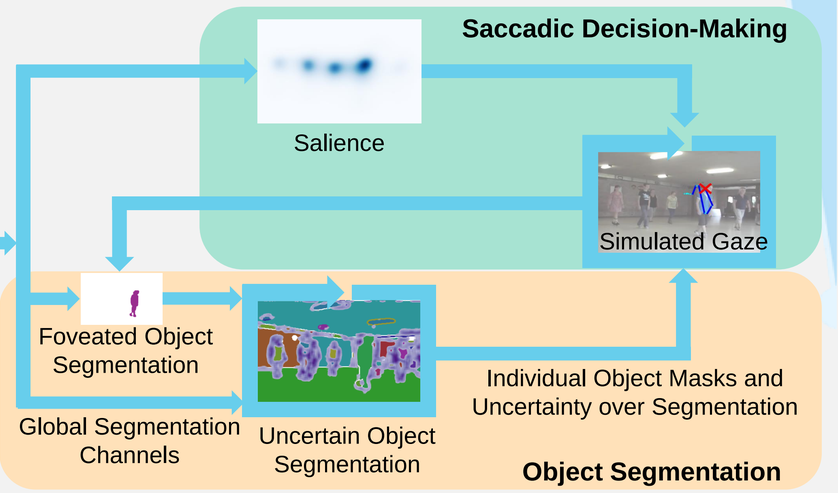
Reflect ***Weak-Decomposability*** by enabling rich interaction between components with overlapping information.

Computational Patterns Addressing the Common Properties

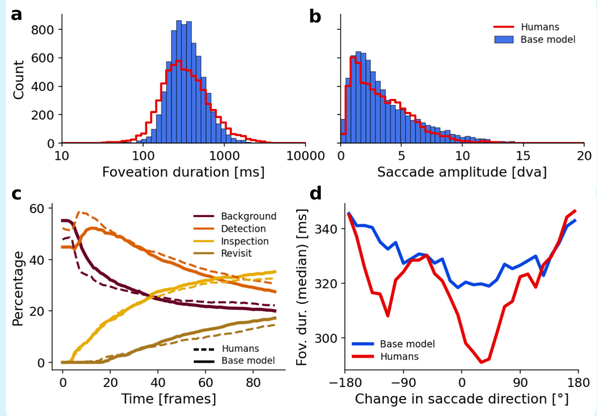
Modelling Human Vision

AICON is not only a useful tool to build robust synthetic systems, but reflects many assumptions on information processing in biological systems. We investigate this resemblance by employing AICON to model biological behavior, currently focusing on human vision in a ***collaboration with project 1.***

Videoframe

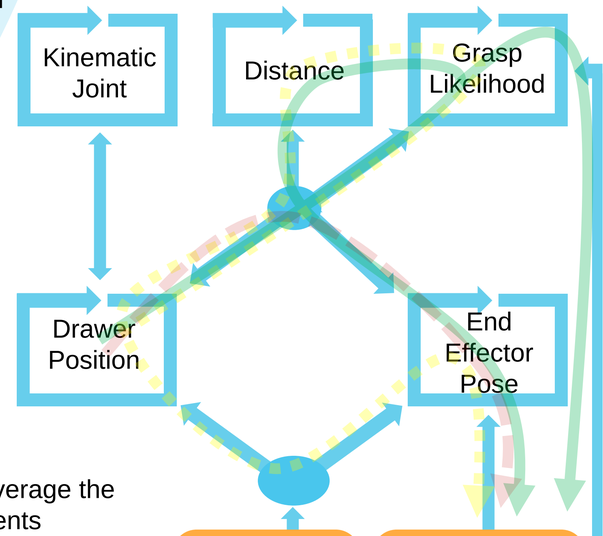


Human vs. Model Behavior



The ***related project 2*** also uses AICON to model human vision, but focusing on visual illusions.

Robotic Action Selection



AICON models can also generate behavior, if we leverage the different gradients in the model. With different gradients (different colors on the right) different behaviors emerge (below). The system cannot just produce these different behaviors but also adaptively select between them to robustly solve tasks such as drawer opening.

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