1. Introduction and Problem Statement

Perception improves with experience, the acquisition of new exploration capabilities, and the development of new perception-action routines [1], such that internal representations are continuously refined to support more precise motor planning [2]. Both real and artificial systems reliably extract information from their noisy environment and build an internal representation of it.

In this poster, we present the synthesis process of a distributed cortically inspired processing scheme for multisensory fusion. The initial structure is continuously adapted given available sensory inputs, by learning inter-sensory dependencies, and at the same time converging to a coherent representation of the sensory space and the cross-sensory relations. Using a distributed processing scheme, based on localized intelligence with asynchronous information exchange and adaptation based on external sensory stimuli, the framework provides a fast, robust and scalable architecture appropriate for real-time applications.

We instantiated the developed framework in various robotic scenarios: heading estimation and path integration for wheeled mobile robots [3] and 3D egomotion estimation for flying quadrotors. Alleviating the need for tedious design and parameterization, usually required in classical, dedicated sensor fusion models [4], the framework is attractive for robotic applications coping with increasingly complex operating environments.

3. Experimental Setup and Model Instantiation

As basic testing scenario, we consider a quadrotor (Figure 2a) hovering in an uncluttered environment, while an overhead camera system keeps track of its position and orientation in the 3-dimensional space (Figure 2b).

![Figure 2. Experimental setup: a) Quadrotor platform; b) Reference system alignment and ground truth camera tracking system.](image)

**Model details**
- all-to-all connections between available sensory representations, Figure 3b
- enforce coherent correlations for subsequent fusion, Figure 3b, c
- sensory associations based on underlying entropy of information content
- represent the dynamics of the robotic system, Figure 3a
- consistent with recently developed modelling and control [4]

4. Experimental Results

- learned sensory relations (Figure 4a) resemble the underlying nonlinear functions (i.e. arctangent) and capture data irregularities
- learned relations balance sensory contributions to obey the relation (Figure 1b) to cancel individual estimation errors (e.g. accelerometer noise, gyroscope drift)
- learned relations are decoded for enforcing the values sensors can have
- individual angle estimates are improved by fulfilling the learned relations between sensors, Figure 4b
- inferred egomotion estimates are robust with respect to noise and drift but not to intrinsic effects (e.g. magnetometer offset)

- given noisy sensory data, the model infers precise estimates of egomotion

![Figure 3. Instantiation for quadrotor 3D egomotion estimation: network structure and sensory associations. a) Sensor configuration; b) Interacting network connectivity; c) Sensory associations for learning.](image)

![Figure 4. Learned relations: a) Input data resembling a nonlinear relation and its distribution; b) Model output showing learned new relation and its distribution.](image)

5. Conclusions

We proposed and evaluated a learning model able to:
- use simple and computationally effective processing mechanisms to capture the intrinsic correlational structure and statistics of sensors data
- use efficient representation and computation mechanisms without prior assumptions, in order to alleviate the need for tedious design and parameterisation
- provide precise egomotion estimates for a quadrotor by unsupervisedly learning multisensory integration rules from available sensory streams

References