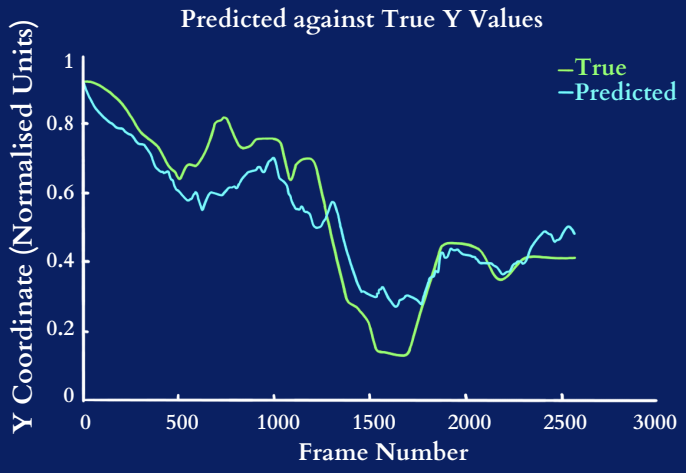
Model Performance

Our tuned model was evaluated on an unseen validation set of images, and predicted coordinates were plotted against ground-truth values:



Key Contributions:

- Generate realistic and varied synthetic image data to train and test model
- Trained model that is largely invariant to lighting changes and visual noise
- Developed techniques to visualise model filters and activation curves
- Filters learned by network resembled biological receptive fields of the PVC
- Demonstrated potential for Place Cell-like encoding of spatial location

Our Next steps

1. Continue parameter tuning to improve the model's accuracy
2. Expanding the training set to different environments and lighting conditions to develop more general filters [6]
3. Remove inactive neurones and reduce precision of calculations to decrease model size for embedded applications [7]

Contact Us

For general enquiries :

a.bharath@ic.ac.uk

Department of Bioengineering,
Imperial College London,
Exhibition Road,
London SW7 2AZ

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For References, Videos, and our Full Report

Imperial College London

Place Cell Modelling

Indoor Self-Localization using Convolutional Neural Networks

Motivation

Self-localisation is the ability of an agent to recognise its position and orientation in an environment. Current self-localisation algorithms suffer from certain limitations [1]:

- Sensitive to lighting changes
- Detailed location requirements
- Excessive computation costs

We aimed to create a model that excels in these areas, to be used in conjunction with existing systems and complement their weaknesses.

Biological Inspiration

Mammals are able to orient themselves in a variety of environments in a way that is flexible, robust and efficient [2].

Specialised neurones called Place Cells are found in the Hippocampus. They encode spatial position through their rate of firing [3], making them an excellent basis for a self-localisation model [4].

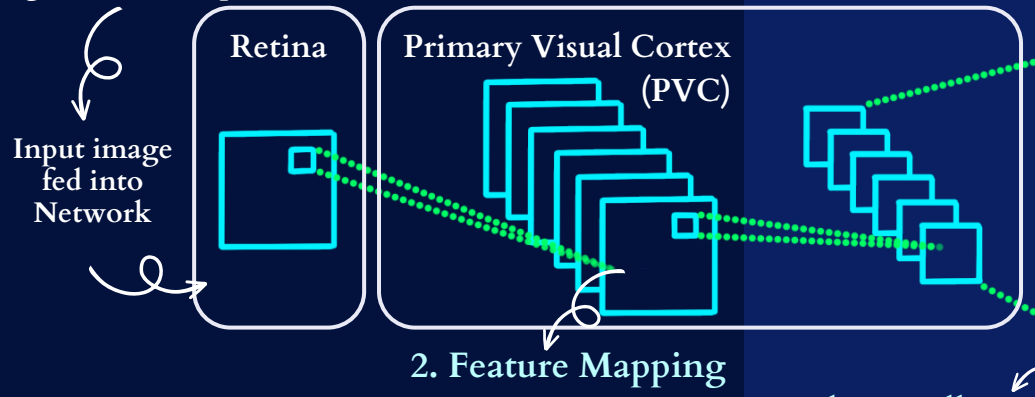
Aims

- Design a Convolutional Neural Network (CNN) that is inspired by the mammalian visual system, to predict 2D spatial coordinates and direction from input images
- Update its parameters via backpropagation to minimise the Mean Squared Error of predicted coordinates
- Investigate for biological behaviour

Model Front End

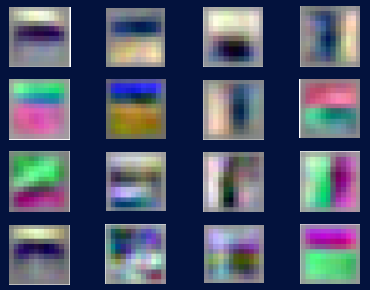
1. Input and Dataset Generation

A **virtual home environment** was created with a variety of materials, textures, colours, shapes and lighting, to generate varied **training** and **testing** datasets. This increased the model's robustness and generalisation power.

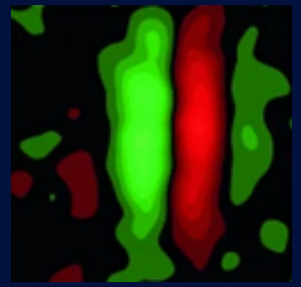


2. Feature Mapping

Images are mapped using filters learnt by the model. The network filters indicate learning of structural features, orientation-selectivity and colour patterns, comparable to the receptive fields of human V1 cells of the PVC [5].



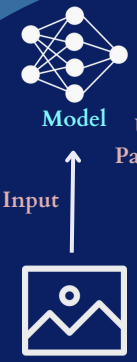
Network Filters



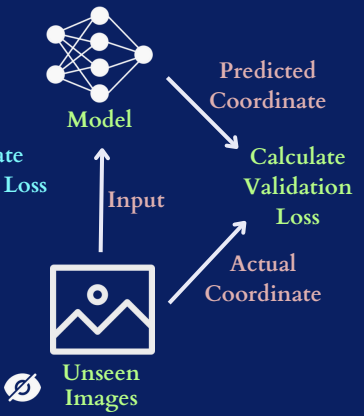
V1 Receptive Field

Model Back End

Model Training

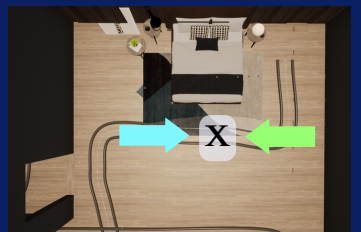


Model Testing



3. Place Cell Layer

Encodes spatial information. Visualising the activations of certain neurones in this layer indicated strong positional selectivity regardless of camera angle, e.g:



Direction invariance of Neurone 26 at position X.