Demo: A Demonstration of Tracking using Dynamic Neural Fields on a Programmable Vision Chip

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ABSTRACT

A demonstration is made of a programmable vision chip, containing an array of photosensors collocated with a processing circuitry and memory, implementing a Dynamic Neural Field (DNF) over a simple saliency map. The system detects and tracks moving objects with strong contrasts. The computation of the DNF's dynamics is performed entirely on the vision chip. The system solely outputs relevant information that has been processed on the array: the activity of the DNF and/or address-events corresponding to the coordinates of its bumps of activity.

Keywords

Dynamic Neural Fields; Vision chip; Tracking; Cellular Processor Array; Cellular Neural Network, Neuromorphic artificial vision

1. INTRODUCTION

Smart cameras benefit from advances in microelectronics technologies, allowing them to embed more processing features and run at low power. The integration of processing and sensing in the same device enables a tighter integration of the algorithm and the capture of visual information. In this work we take advantage of this integration and present a tracking algorithm running solely on a vision chip device [1]. The vision chip - which includes a processing element in each pixel of the imaging array - is used to acquire visual data and perform local operations on each pixel independently. Even though the process of tracking is typically thought as a non-local computation, we suggest the use of a local connectivity of a Dynamic Neural Field (DNF). A DNF is a dynamical system originally inspired from the activity of neural populations and amounts to an activation function defined over a space of one or several dimensions. The lateral interactions of the DNF allow us to formulate tracking using local operations. This demonstration presents a prototype of our system performing tracking in a "surveillance" setup, in which the camera is fixed looking at a scene exhibiting moving objects.

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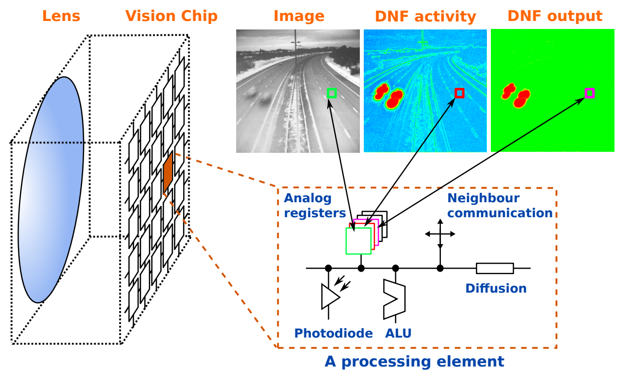


Figure 1: An illustration of our system: a vision chip with processing capabilities is in the image plane of a lens, each processing element holds in its registers a pixel of the image, of the DNF activity and output.

2. SYSTEM DESCRIPTION

The tracking system demonstrated in this work is presented in greater detail in [2]. It comprises a programmable vision chip on which a DNF implementation runs over a saliency map. The chip contains photosensitive elements enabling the capture of video frames. While the light integration for a frame takes place, the processing of the previous frame happens in parallel. This processing comprises the computation of a simple saliency map and the simulation of the DNF. The saliency map is the weighted sum of a spatial gradient and a temporal gradient over the light intensity in the current and previous frame. It is used as the input signal to the DNF. The simulation of the DNF is carried out on the chip, permitting many iterations–in the order of hundreds per frame–as described next.

Dynamic Neural Fields.

DNFs were originally derived as a mathematical description of activity patterns in large neuronal populations in the cortex [3]. A DNF is a continuous activation function, spanned over a space of one or several dimensions, e.g. the image plane. The activation function follows an attractor dynamics, shaped by the inputs to the DNF, a non-linear thresholding output function, and lateral interactions between different locations in the DNF. The lateral interac-

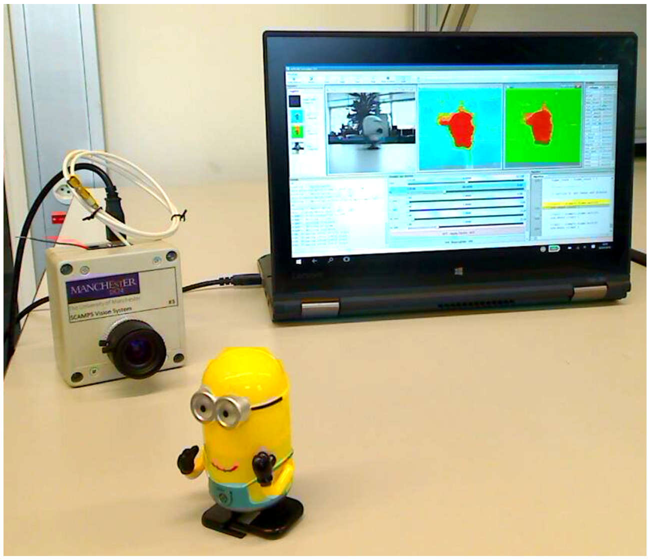


Figure 2: The setup presented in this demonstration: A SCAMP-5 vision box (left) contains the vision chip and a FPGA to dispatch instructions and interface it with a computer (right) to program and interact with the box.

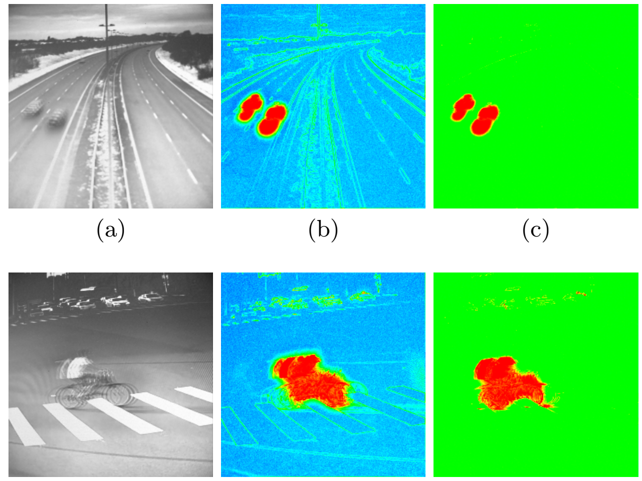
tions typically have a short-range excitation / long-range inhibition pattern and lead to stability of a particular solution of the DNF equation: a localised bump of suprathreshold activity. These localised bumps have the following properties, important for our tracking application: they stabilise a "detection" decision for a particular object against spatial and temporal noise and distractors, they allow to select among alternative objects, and they perform a spatial and temporal smoothing, facilitating tracking of the selected object.

SCAMP-5, a programmable vision-chip.

The programmable vision chip we demonstrate [1] features a Cellular Processor Array (CPA), i.e. an array of cells that can perform computation on their own local piece of data and communicate with their neighbours. The array includes photosensitive elements, one pixel per processor. One of the main advantages of such devices is their ability to process visual information directly where it is collected, thus avoiding the traditional bandwidth bottleneck between a sensor and a processor. In particular, SCAMP-5 processing elements contain an analog Arithmetic and Logic Unit and memories, as well as a few single bit digital registers. This mixed-signal design allows a good trade-off between the features available, compact implementation, and low power consumption.

A match between DNFs and SCAMP.

DNFs are good candidates to an implementation on a CPA due to the nature of their local computation. One unit of the DNF naturally maps to one cell in the array, thanks to the processing circuitry at each pixel and the communication between neighbours. On the SCAMP-5 chip, the dynamics of the DNF can be simulated with up to more than 300 iterations per frame at 25 frames per second. The non-linear activation function of the DNF comes for free with the use of saturating analog registers on-chip and a resistive network allows to perform approximate gaussian convolutions to implement proximal excitation and distal inhibition of the DNF very efficiently.



(a) (b) (c)

(d) (e) (f)

Figure 3: (a)(d) Frames of the video sequences (b)(e) activity in the DNF on the vision-chip (c)(f), and output of the DNF for two videos with road scenes.

3. DEMONSTRATION

The demonstration consists of a SCAMP-5 vision chip implementing a saliency map and a DNF connected to a laptop running a visualisation software. The output consists in the DNF activity, the non-linearly thresholded activity, as well as event-based output of the coordinates of the centers of the activity bumps. These outputs form colored "traces" in time showing how objects are tracked.

The user can interact with our system by adjusting the different parameters of the DNF and saliency map and explore their effects on the performance of tracking. The number of iterations of the DNF for each input, the level of input of the saliency to the DNF, its resting potential, the shape of its inhibition and excitation kernels can be changed in a live interface allowing to immediately inspect the DNF outputs. The performance of the system will be demonstrated on video-streams as well as in an interactive session during which the visitor can participate and validate the system.

4. ACKNOWLEDGEMENTS

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