ÚJ SZÉCHENYI TERV

3D Spatio-Temporal Movement Detection with Adaptively Tuned 2D Active Sensorarray

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MAGYARORSZÁG MEGÚJUL

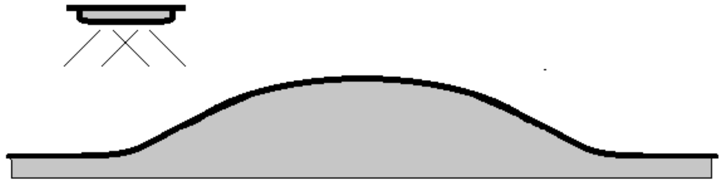
A projekt az Európai Unió támogatásával valósul meg.

Outline

- **the aim:** to detect spatio-temporal features or events
- **the computational environment:**
  a cellular wave computer architecture, where the computations are done by locally propagating waves.
  The active light of the sensors can be adaptively tuned in spatio-temporal.
- **system setup:**
  computational method: software simulation
  hardware framework: infrared lighting and sensorarray
- spatio-temporal algorithms
- measurement and simulation **results**

What to detect?

- **objects** with bigger size than the sensorarray itself (Problem No. 1.)
- spatial-temporal **motifs** with changing position and intensity during time-evolution (Problem No. 3.)
- spatial-temporal **events** defined by the motifs



A useful technique:

to extend the measurement range **locally** and **adaptively** (Problem No. 2.)

The wave instruction

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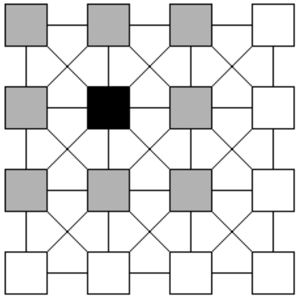


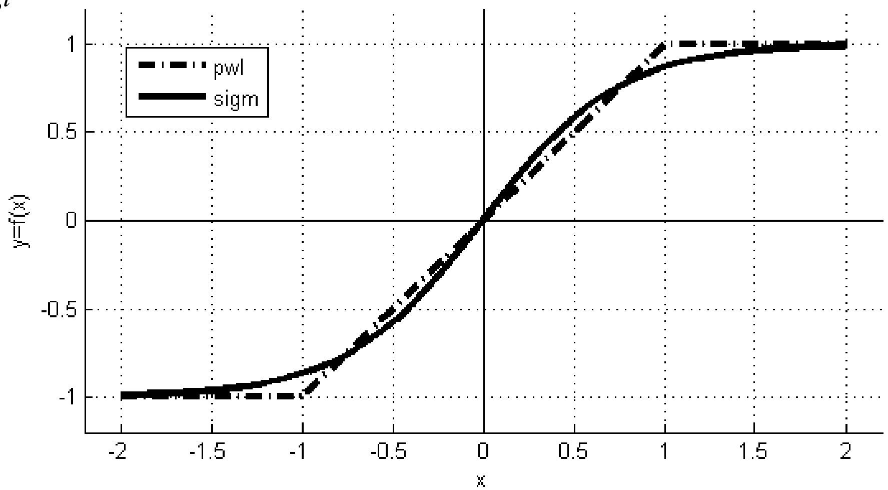
$$A = \begin{matrix} a_{-1,-1} & a_{-1,0} & a_{-1,1} \\ a_{0,-1} & a_{0,0} & a_{0,1} \\ a_{1,-1} & a_{1,0} & a_{1,1} \end{matrix} \quad B = \begin{matrix} b_{-1,-1} & b_{-1,0} & b_{-1,1} \\ b_{0,-1} & b_{0,0} & b_{0,1} \\ b_{1,-1} & b_{1,0} & b_{1,1} \end{matrix} \quad z = z$$

$$\dot{x}_{i,j} = -x_{i,j} + \sum_{k,l \in S_{i,j}} a_{i,j,k,l} f_1(x_{k,l}) + \sum_{k,l \in S_{i,j}} b_{i,j,k,l} u_{k,l} + z$$

$f_{pwl}(x) = \frac{1}{2}$ [redacted] $x +$ [redacted] $x -$ [redacted]

$f_{sigm}(x) = 2(\frac{1}{1+e^{-ax}}$ [redacted] $- 0.5)$

$$a = 2.65$$



The computational model

We have **three dynamics** evolving together:

- the dynamics of the input flow (***u***)
- the self-dynamics of the computing cellular array (***F***)
- the dynamics of the active light-sources (***G1, G2***)

We are interested in their **interaction**.

Dependence-relations: 'independent' case

$$\left.\begin{aligned}\dot{x} &= F(x, f_1(x), u)\\ \dot{v} &= G_1(v, f_2(v))\end{aligned}\right\}$$

'dependent' case

$$\left.\begin{aligned}\dot{x} &= F(x, f_1(x), u)\\ \dot{v} &= G_2(v, f_2(v), f_1(x))\end{aligned}\right\}$$

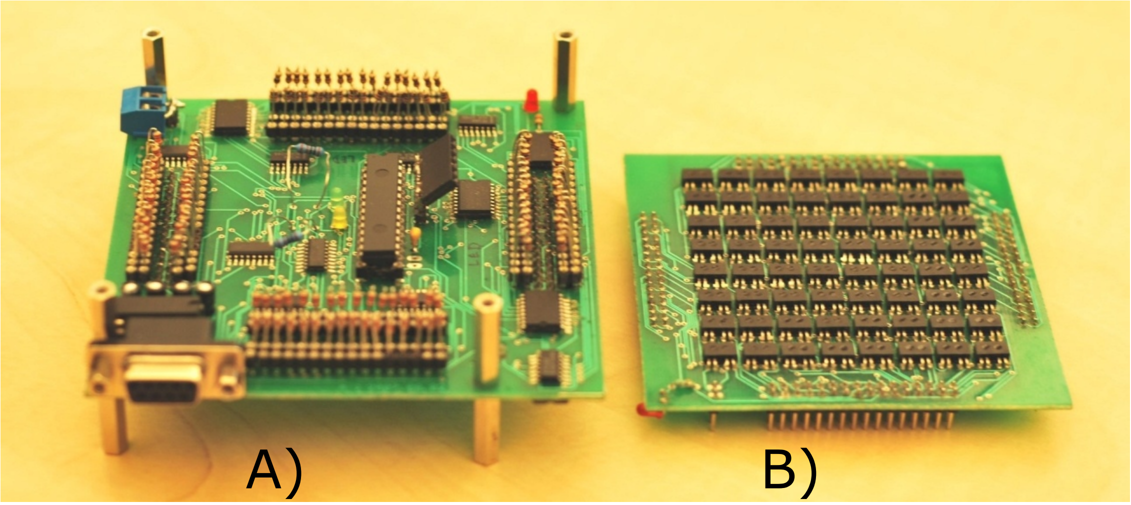
u: two-dimensional input-flow

x: two-dimensional computation-flow (inner state of the cells)

v: two-dimensional flow defining the strength of the light-sources

System setup

Sensorarray:
to collect the input-data from the scene
• A) 8x8 active LED array with receiver sensors
• B) control- and readout-circuits



Simulator:
to process the raw measurement data in the afore mentioned computational model
• state-equations: both explicit Euler and RK-45 methods to approximate
•software framework: c++, MATLAB

Problem No. 1.
to detect oversized objects/features

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The task: to detect a specific terrain feature (a bump or a valley) which has bigger size than the sensorarray itself.

The key step: to apply the whole image flow on the input, instead of the separately captured frames (frameless detection).

input-flow: from a convex surface

lighting dynamics: uniform and constant on a moving (see '→') array

emerging pattern-dynamics: depends on the terrain region (Pattern 1, Pattern 2 or Pattern 3)

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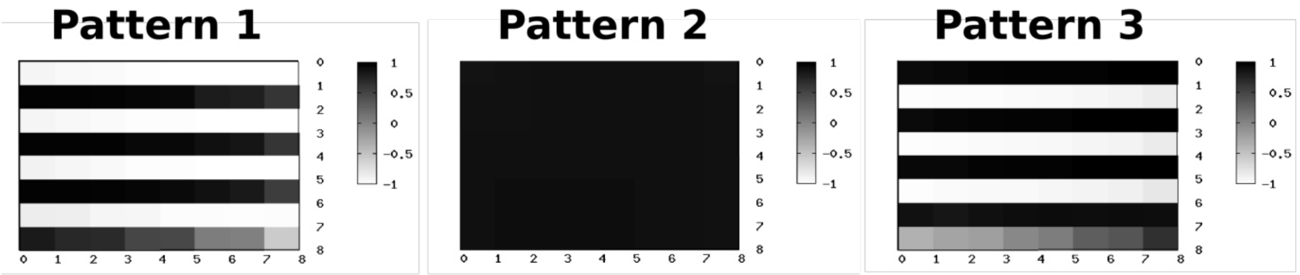
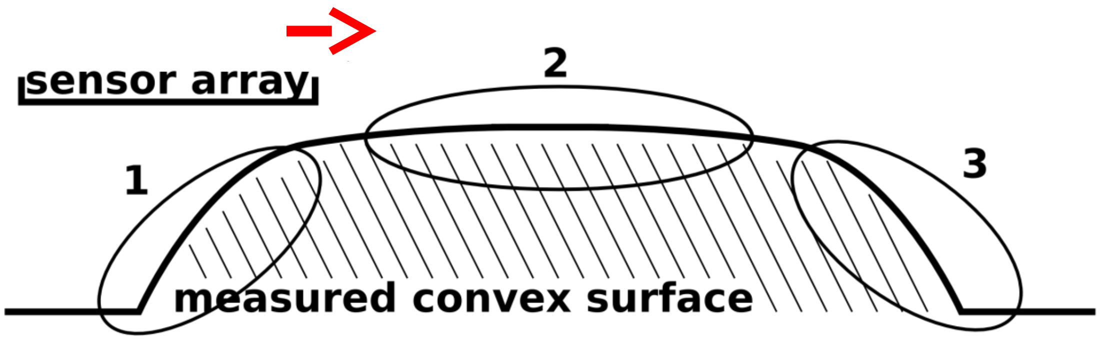
Problem No. 1.
to detect oversized objects/features

$$A = \begin{matrix} 0 & 0 & 0 \\ s & p & -s \\ 0 & r & 0 \end{matrix}$$

$$B = \begin{matrix} 0 & 0 & 0 \\ 0 & b & 0 \\ 0 & 0 & 0 \end{matrix}$$

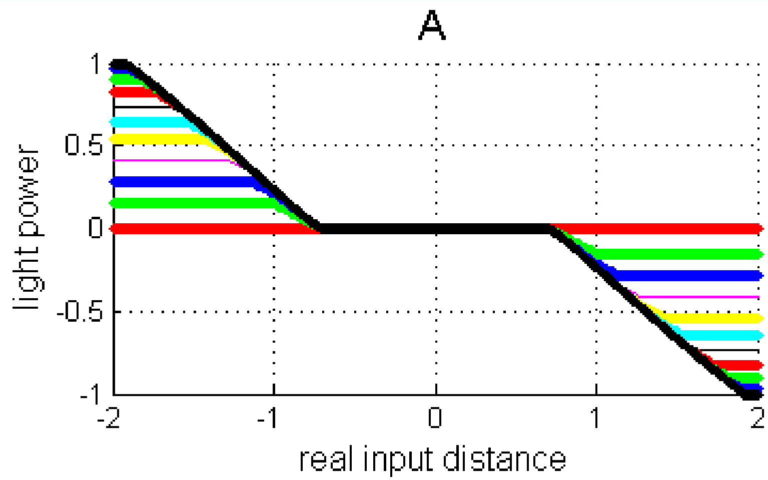
$$z = z$$

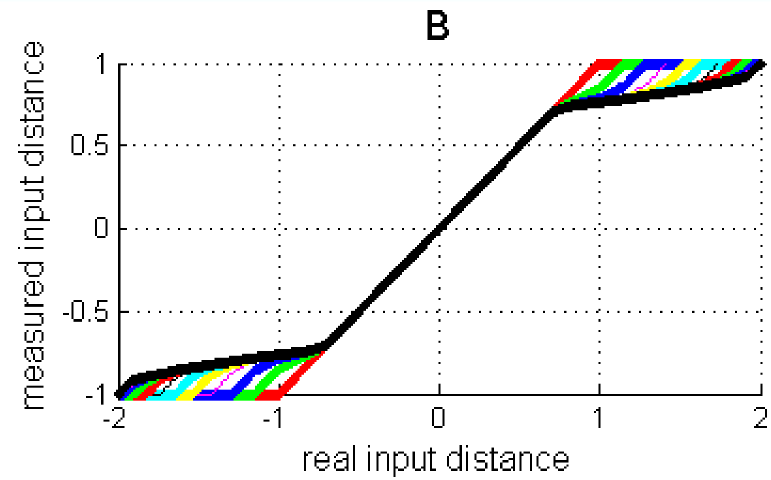


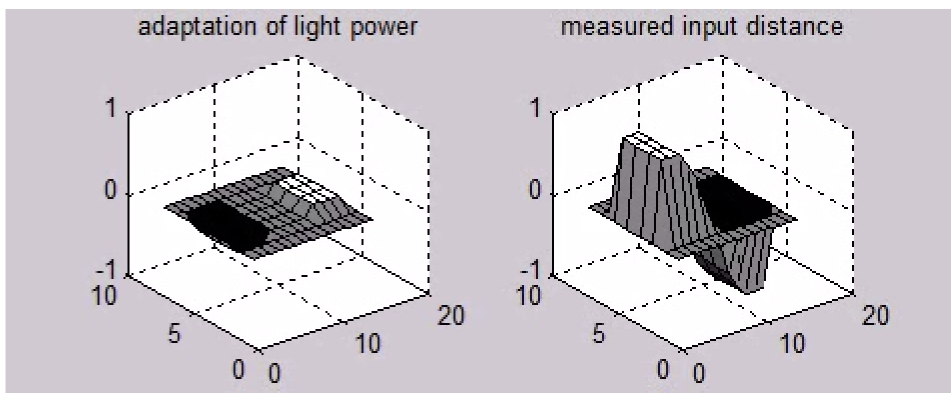


$$T: \begin{matrix} s = 1.1, & p = 1.0, & r = -0.6, \\ b = 1.0, & z = 0.0 & \end{matrix}$$

Problem No. 2.
locally and adaptively tune the activation light







Problem No. 3.
to detect spatio-temporal motifs

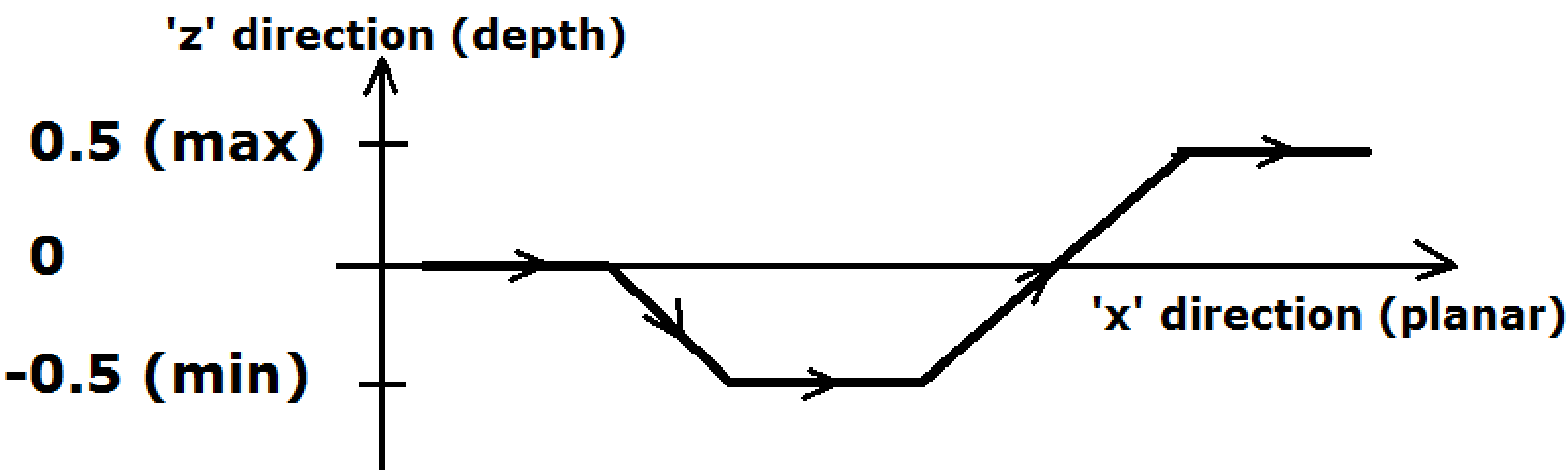
The task: to detect/recognize those objects which are moving on a perpendicular (compared to the sensor array) 2D plane with a constant velocity.

The key step: the summed squares of the two velocity vectors' projections is constant.

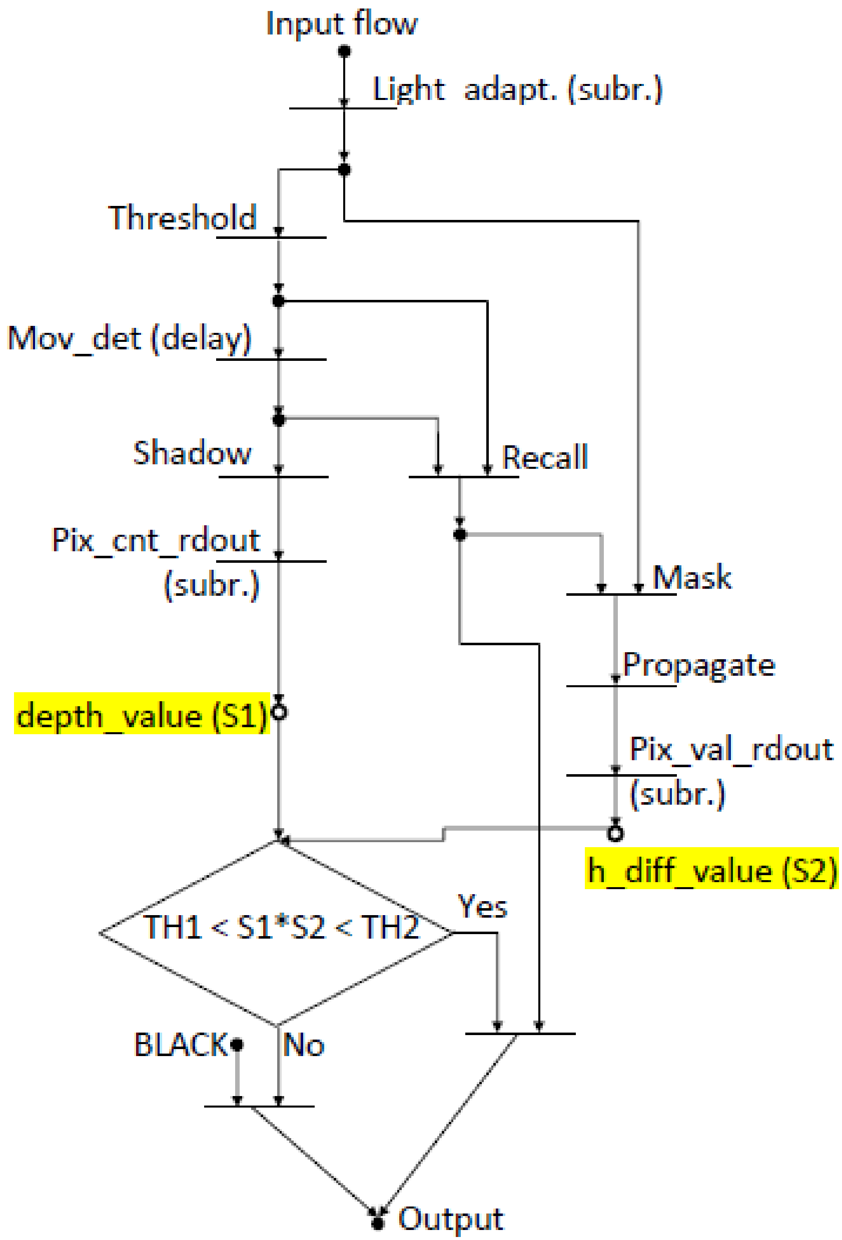
$$\sqrt{v_x^2 + v_z^2} = v_r = const.$$

Decomposition needed:

- to compute the planar-component of the velocity vector
- to compute the depth-component of the velocity vector



Problem No. 3.
to detect spatio-temporal motifs



Problem No. 3.
to detect spatio-temporal motifs

When the **magnitude of the planar-component** of the velocity-vector is constant:

Problem No. 3.
to detect spatio-temporal motifs

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When the **magnitude of the resultant** velocity-vector is constant:

Take-home message

- detecting spatio-temporal motifs or events
- the computation of the standard Cellular Wave Computer is extended with the dynamics of the light-sources
- examples:
  - features with bigger size, than the size of the sensorarray itself
  - the local and adaptive extension of the measurement's depth-range
  - detection of movements with constant magnitude velocity

Thank you for your kind attention!