Marching Pixels

seit 1548

Friedrich-Schiller-Universität Jena
Institut für Informatik
Technische Informatik II

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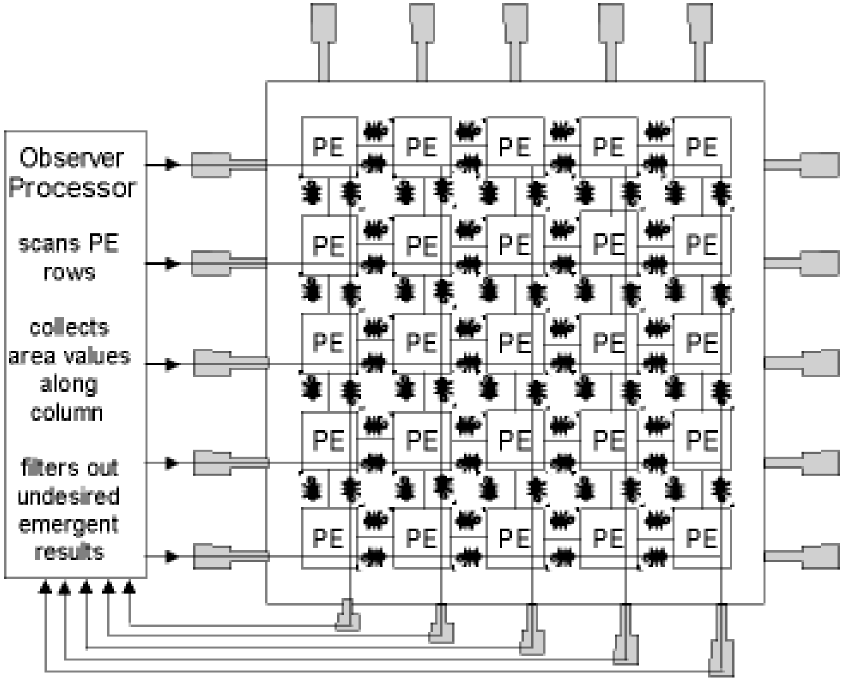
Initial Problem - Manual development of desired emergence

- Find Marching Pixel algorithms
  - Find centroid, area, edge length, orientation
  - Multiple objects
  - Harsh constrains
  - How is this done best?
- Find appropriate hardware structure



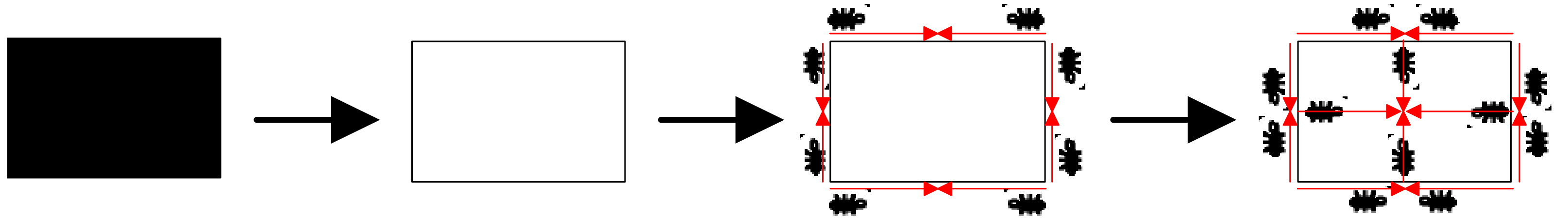
Agenda

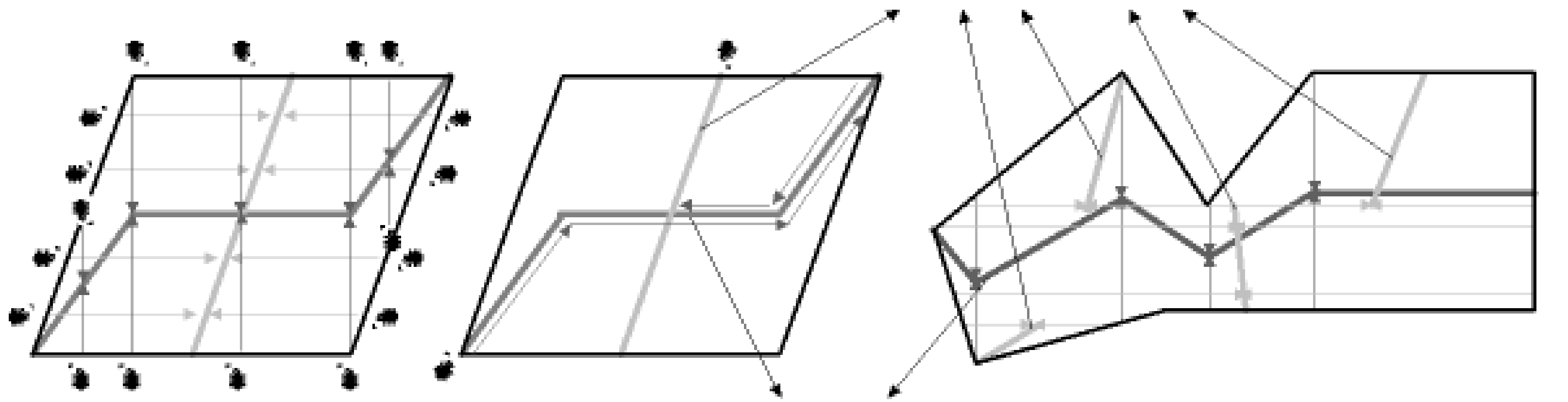
- Results of the First Phase
  - MP Toolbox
  - Evolved Emergence
  - Realisation in Hardware
- Goals of the Second Phase
  - Prototype chip
  - Generic emergent fine-grained computing model
  - Applications

Results of the First Phase

MP Toolbox – Edge Run, Reduction Lines

- Different objects -> different algorithms





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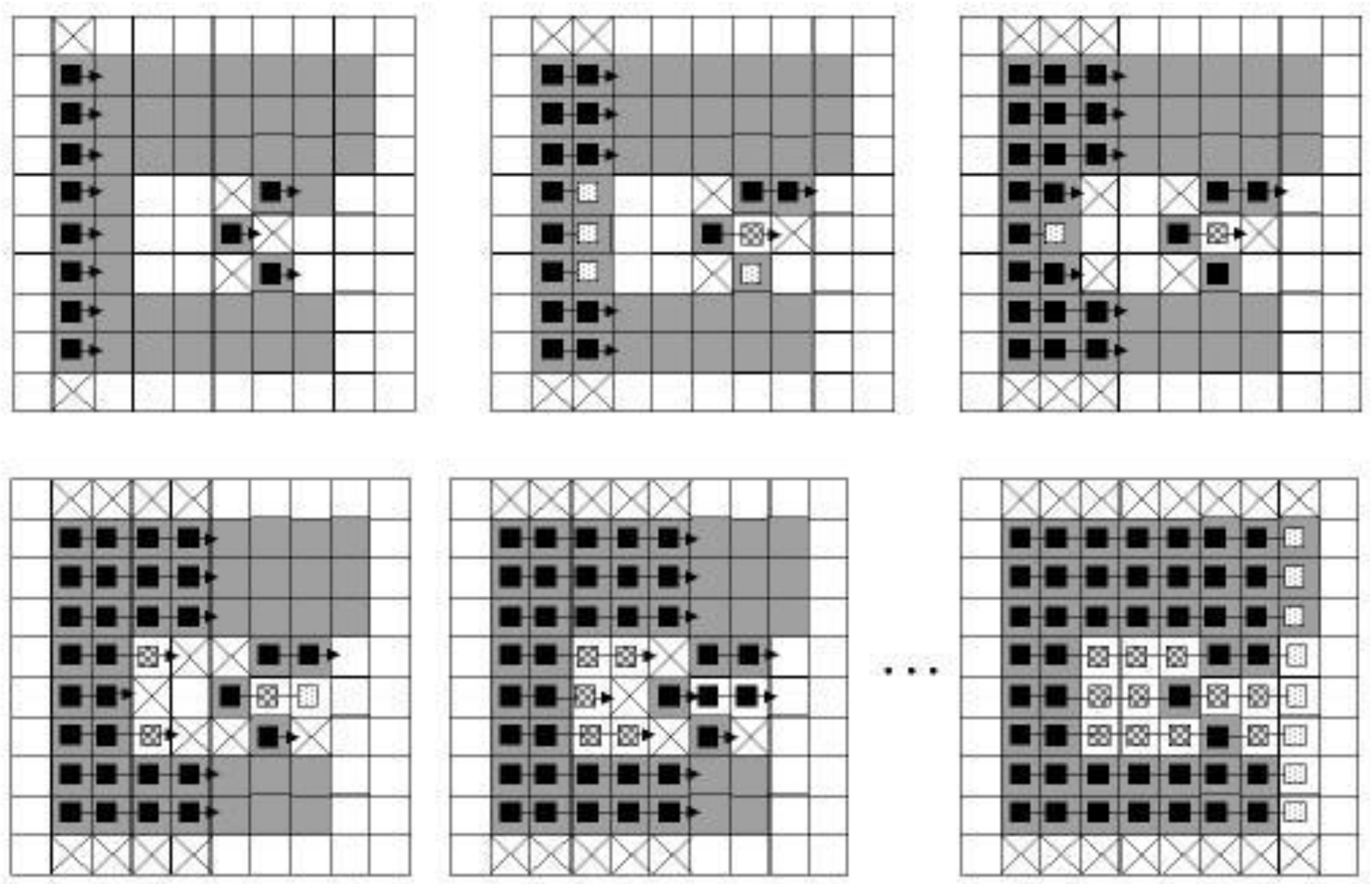
MP Toolbox - Flooding



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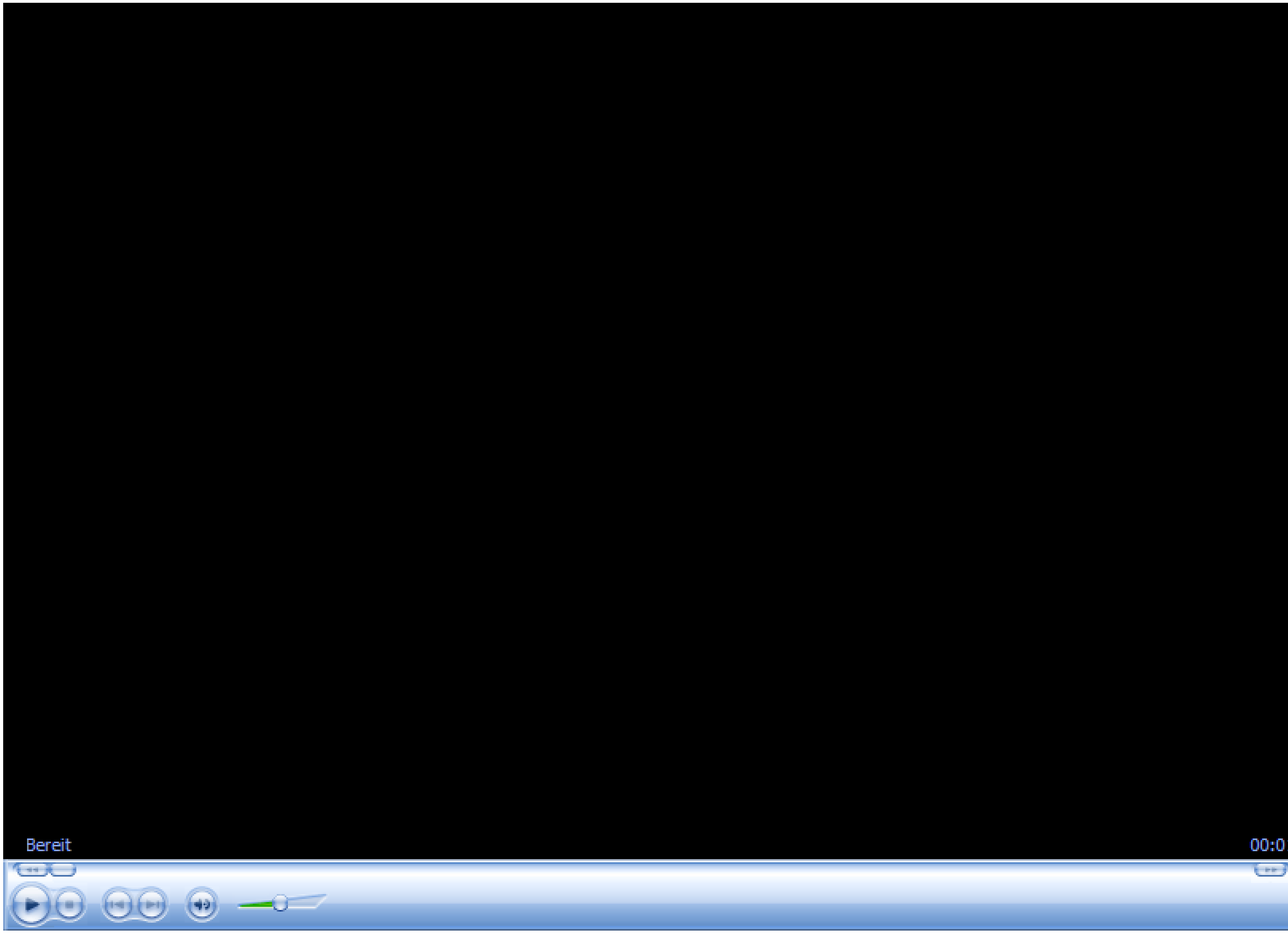
MP Toolbox - Flooding



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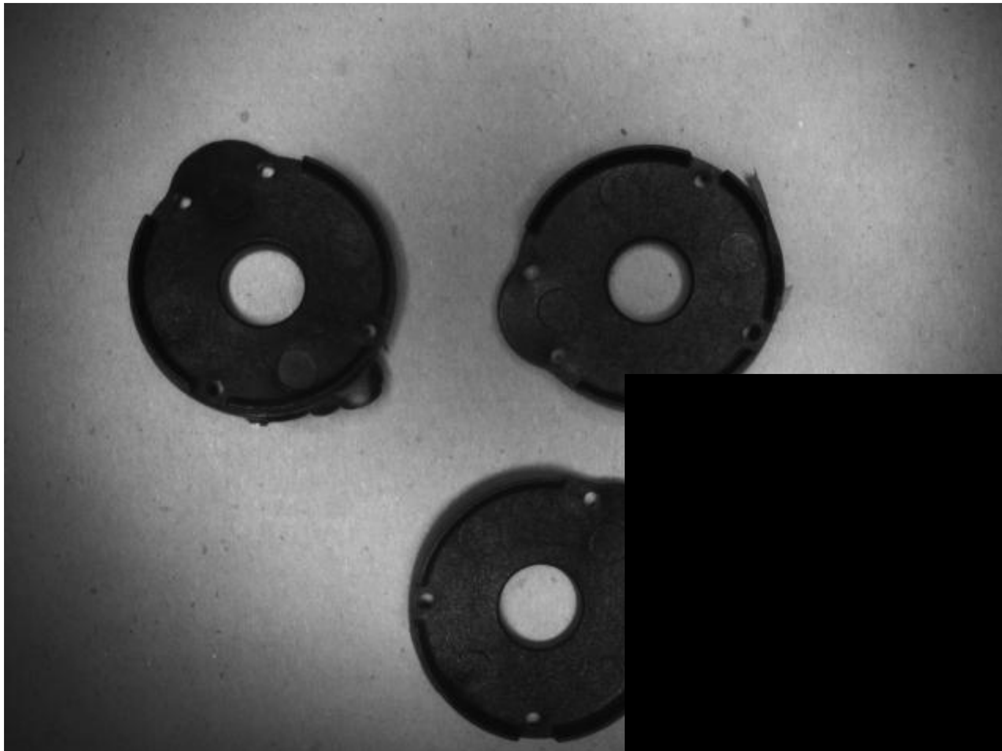
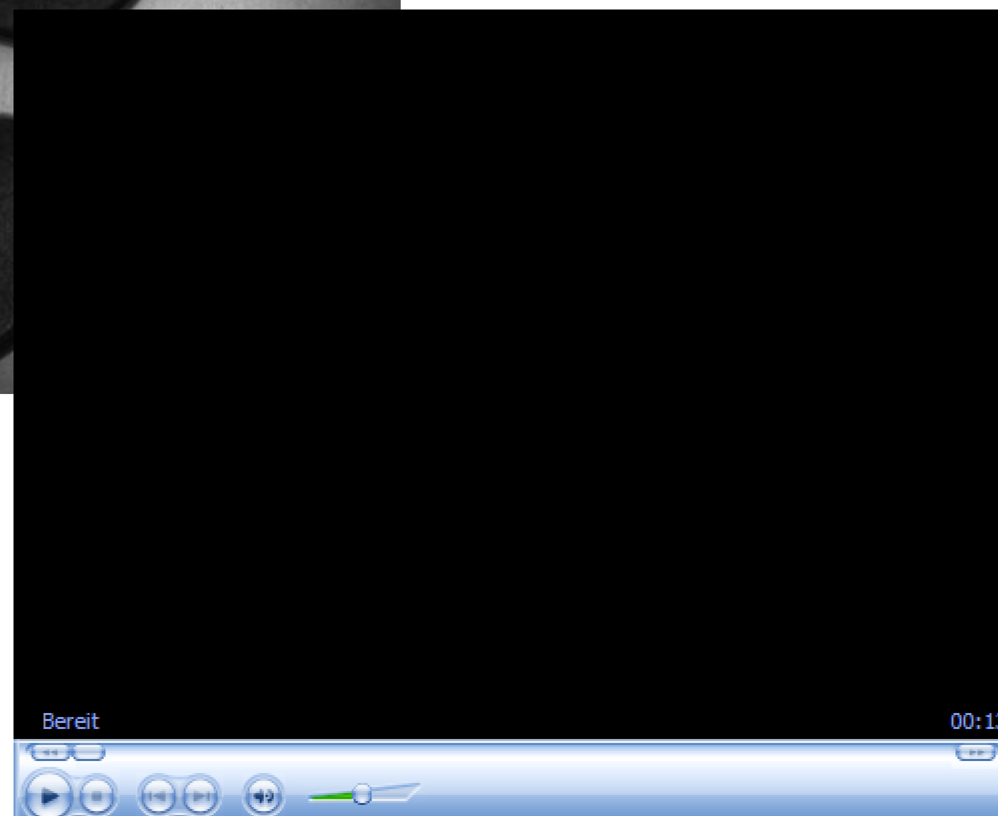
MP Toolbox – Opposite Flooding





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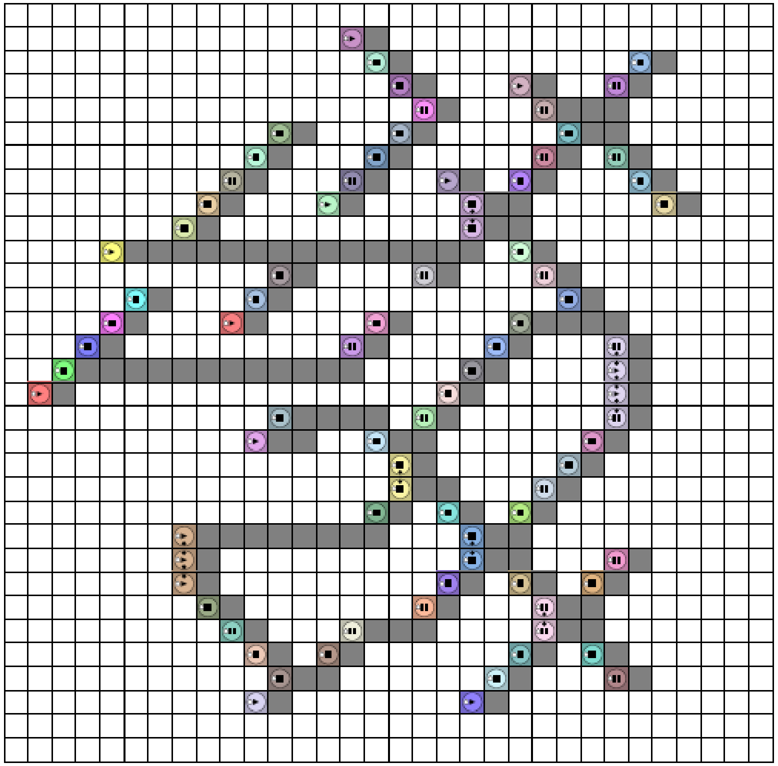
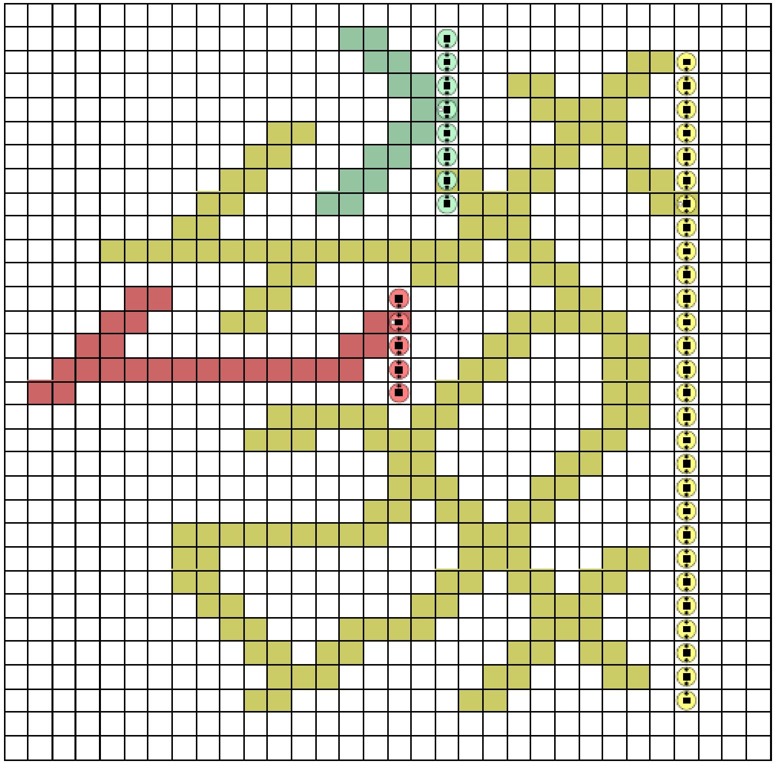
Algorithm with best attributes

- Cooperation with Braunschweig





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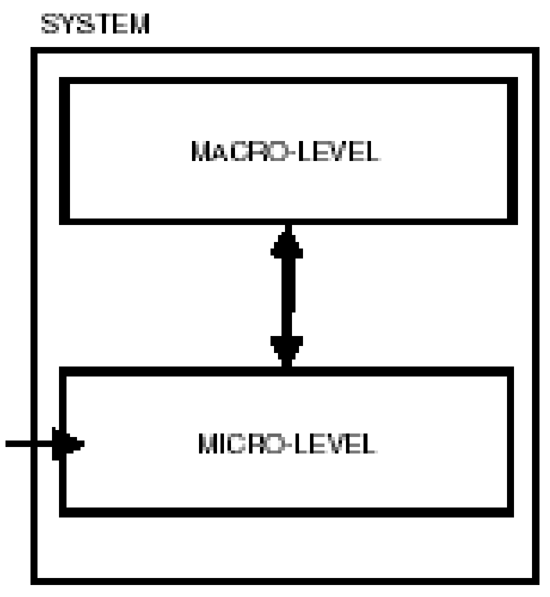
Evolved Emergence

- Which algorithms exploit hardware structure best?



- **how to find the desired micro-macro-effect?**
- **global patterns are known**

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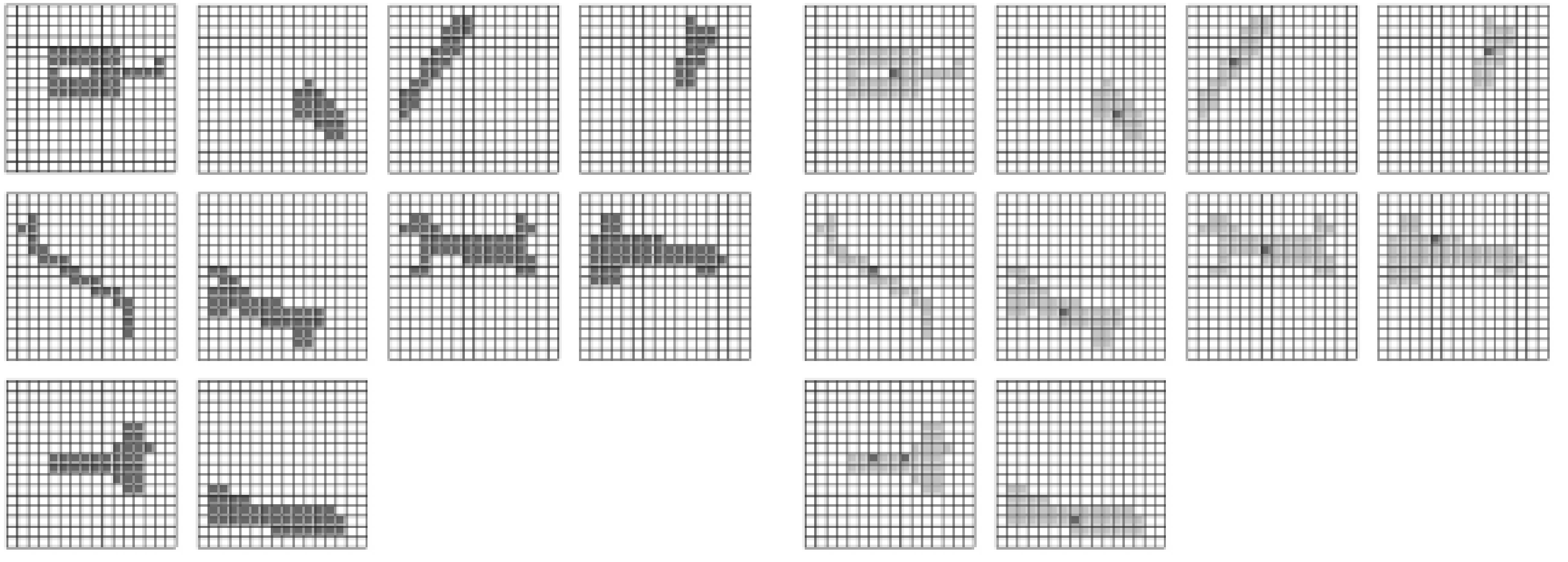
Evolved Emergence

- Algorithms can be found by
  - Manual engineering
  - Evolution
- Desired behaviour is evolved
- Initial rules → Evolve with specific Input → More efficient rules



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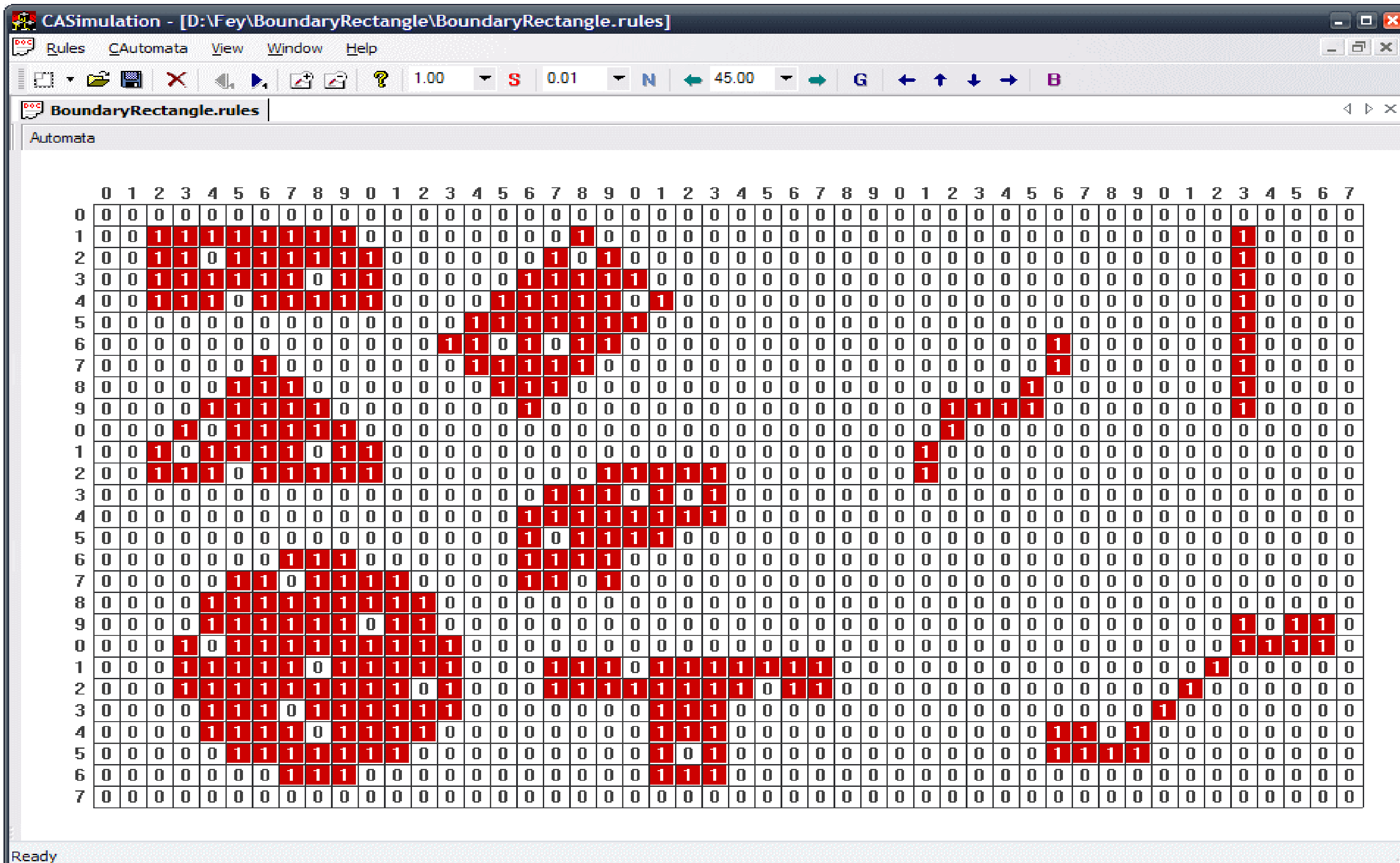
2D-CA

- Calculation of centroid in y-direction



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Evolved Emergence - Genetic Programming

- Genetic algorithms are not sufficient
  - Whole rule has to be encoded but not all is used
  - Search space grows exponentially
  - Only centroid is retrieved
  - Restriction to few states is counter-productive
  - Not stable for unlearned objects

- => Virtual agents
  - Some functionality
  - Some arithmetic operations
  - Cooperation
  - Steered with small programmes => Genetic programming

Result of GP - Centroid, two agents

Instructions:

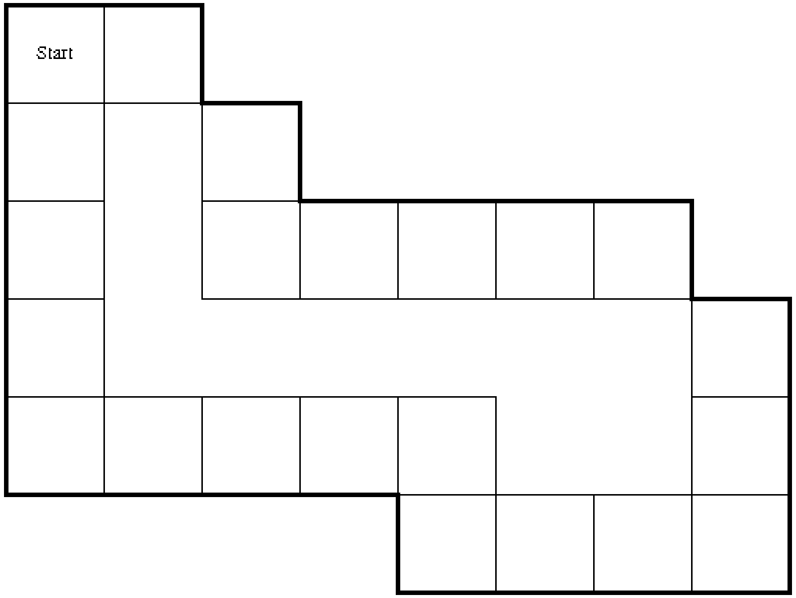
Terminals = {turn_left, turn_right, step_forward, noop}

Functions = {prog2, if_pixel_ahead, if_agent_ahead }

- Edges known
- Every agent looks in another direction
- Implicit unification

Fitness function: (Minimum)

f = w (pixel – found) + program_size



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Evolved program: (5 instructions)

if_agent_ahead{step_forward, if_pixel_ahead[step_forward, turn_left]}

Evolved Emergence

- Effectivity:
  - Dimensions
  - Choose good fitness function
  - Time to result?
- Efficiency:
  - Short solutions found
  - Sometimes optimal
- GP fits hardware structure best

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Realisation in Hardware

- Specification in VHDL and SystemC
- Synthesis for ASICs (prototype state)
  - *Reduction lines*
    - 256x256 image
    - 0,35 µm CMOS process
    - ⇒ 2x2 cm^2 chip
  - *Flooding*
    - 16x16 image
    - 0,35 µm CMOS process
    - ⇒ 1 mm^2 chip
- FPGA
  - Flooding
    - Xilinx FPGA Spartan3-1000
    - 16x16 image
    - MicroBlaze soft IP RISC processor as observer processor

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Comparison of architectures

Architecture	Resolution	Time
FPGA-Camera (SIMD-Preprocessing + Monoprocessor-Postprocessing)	QVGA 320x240	ms
OPTO-ASIC/-ASIP (SIMD-Preprocessing + Monoprocessor-Postprocessing)	VGA 640x480	ms
OC-Architecture (Synchronised-MIMD + Postprocessing)	arbitrary Largest amount of bits per pixel	µs

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Goals of the Second Phase

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Goals of the Second Phase

- Hardware description

  => Prototype chip for a smart CMOS camera

- Hardware description
- Evolution framework
- Experience with MP Toolbox

  => Enhancement of MP model towards fine-grained emergent generic computing architecture

  - Generic programmable hardware
  - Generic emergent computing model and automated solution retrieval

- Many applications

  => Show feasability

Prototype Chip

- Real industry needs
- Application specific
- Based on appropriate algorithm from MP toolbox

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Generic Emergent Fine-Grained Computing Architecture

- Basis is MP model
- Derive generic programmable hardware
- Build generic framework
  - Exploits evolution
  - Builds appropriate hardware automatically
- Demonstrate feasability with example of robot control

Generic Programmable Hardware (“by hand“)

- Define core operations
- Define required memory
- Find communication protocol
- Create programmable processor element array

=> one architecture for several algorithms

- MuxPE

Generic Framework (automatic)

- Use evolution, CAs, and genetic programming
- Generate emergent microprograms
- Generate appropriate hardware

  => Automatic design

- Solutions are not found fast enough => parameter studies on cluster or CampusGRID

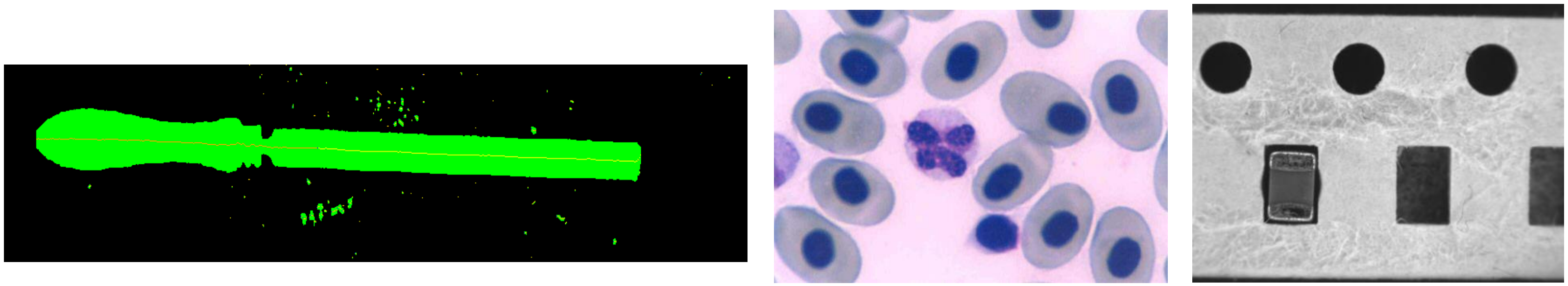
Robustness

- By redundancy

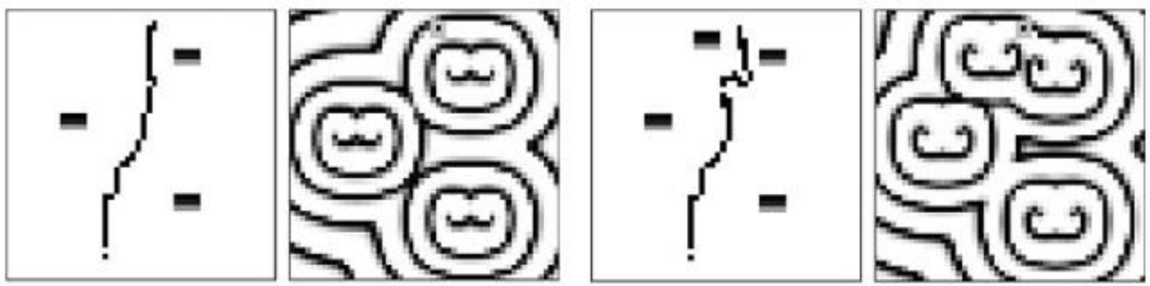
- By upgrade with ASoC
  - First in generic hardware
  - Later in MuxPE
  - Cooperation with Tübingen and Munich

Applications

- Vision in industrial scenarios



- Path planning for mobile robots (OSCAR)



- Gesture recognition

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Thank You

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Teaching

- Part of basic lectures
- Seminar “Organic and Emergent Computing“
- Different study and diploma thesises