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COLLEGE ON NEUROPHYSICS:
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"Neural Mapping for Autonomous Navigation"

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Neural Mapping for Autonomous Navigation

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Collaboration

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- James J. Little

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Overview

- **A Parallel Motion Algorithm**
  - based on voting for consistent motion
  - and winner-take-all
  - implemented on the Connection Machine
- **Neural Mapping**
  - Inverse Perspective
  - simplifies matching
  - from 2D to 1D
  - real-time on PC's
- **Examples**
  - Synthetic Images

Motion Detection Theory

Directional Selectivity

Minimal Requirements

- two inputs
- non-linearity
- asymmetry

Many EMD Algorithms

- Correlation Model (Reichardt)
- Energy Model (Adelson-Bergen)
- Veto Model (Barlow-Levick)
- Shunting Inhibition (Torre-Poggio)

New Parallel Algorithm

- based on biology
- edge-based Alg. motivated by Veto-Scheme
- intensity-based Alg. motivated by Correlation Model

Voting for Motion

Our new parallel algorithm for computing the optical flow is based on the simple assumption, that the optical flow is locally uniform.

Physical constraints on motion limit the spatial variation of the optical flow field.

Constraints

- uniqueness, each image point has a unique velocity
- continuity, surface are locally smooth

This results in a partial solution to the aperture problem

Voting for Motion

- all points in a neighborhood of a feature identify the correct motion
- lines are not disambiguated, since there are no features to match
- heuristic can select the motion of smallest magnitude in case of ambiguity

Edge-based VMA

- **1. find and label edges**
- **2. match edges by shift and compare**
- **1. find local support by counting the matches in a neighborhood of a pixel**
- **1. vote by choosing the displacement which has maximum local support**

Connection Machine Implementation

- **maps easily into CM-architecture**
- **retinotopic mapping into CM-memory**
  [illegible] on g[illegible]
- **one processor per pixel**
- **parallel shift and match operation**
- **each processor keeps record of correct matches**
- **vote for maximum consistency in area**

Advantages of VMA

- facilitates image segmentation
- segmentation not based on output
- segmentation internal to the computational mechanism
- non-iterative ⇨ faster
- not noise-sensitive due to patch integ.
- dense output for intensity-based VMA
- biological plausible (based on Veto- or Correlation Model)
- psychophysical plausible (shows Barber Pole, Motion Capture and other illusions)

Disadvantages of VMA

- fast only on parallel computers

  4 seconds (Connection Machine)
  1 hour (Lisp Machine)
- speed depends on the size of the voting area for serial computers
- size of the voting area depends on the expected velocities

VMA on Serial Machines

is too slow

Solution:

reduce search space

- like in stereo (epipolar lines)
- from 2D (area) to 1D (line)
- by neural mapping

Neural Mapping

- inverse perspective
- talk by Hanspeter Mallot
- flow field on ground plane is known by egomotion
- all flow vectors on ground plane are equal
- deviations in direction and speed are obstacles

Constraints

- velocity [illegible] ground plane is known
- measure egomotion
- eye (camera) parameters are known
- calibrate with egomotion on ground

Examples

- design complex synthetic 3D world
- with solid modelling package
- with known camera parameters:

  focal length of camera

  height above ground

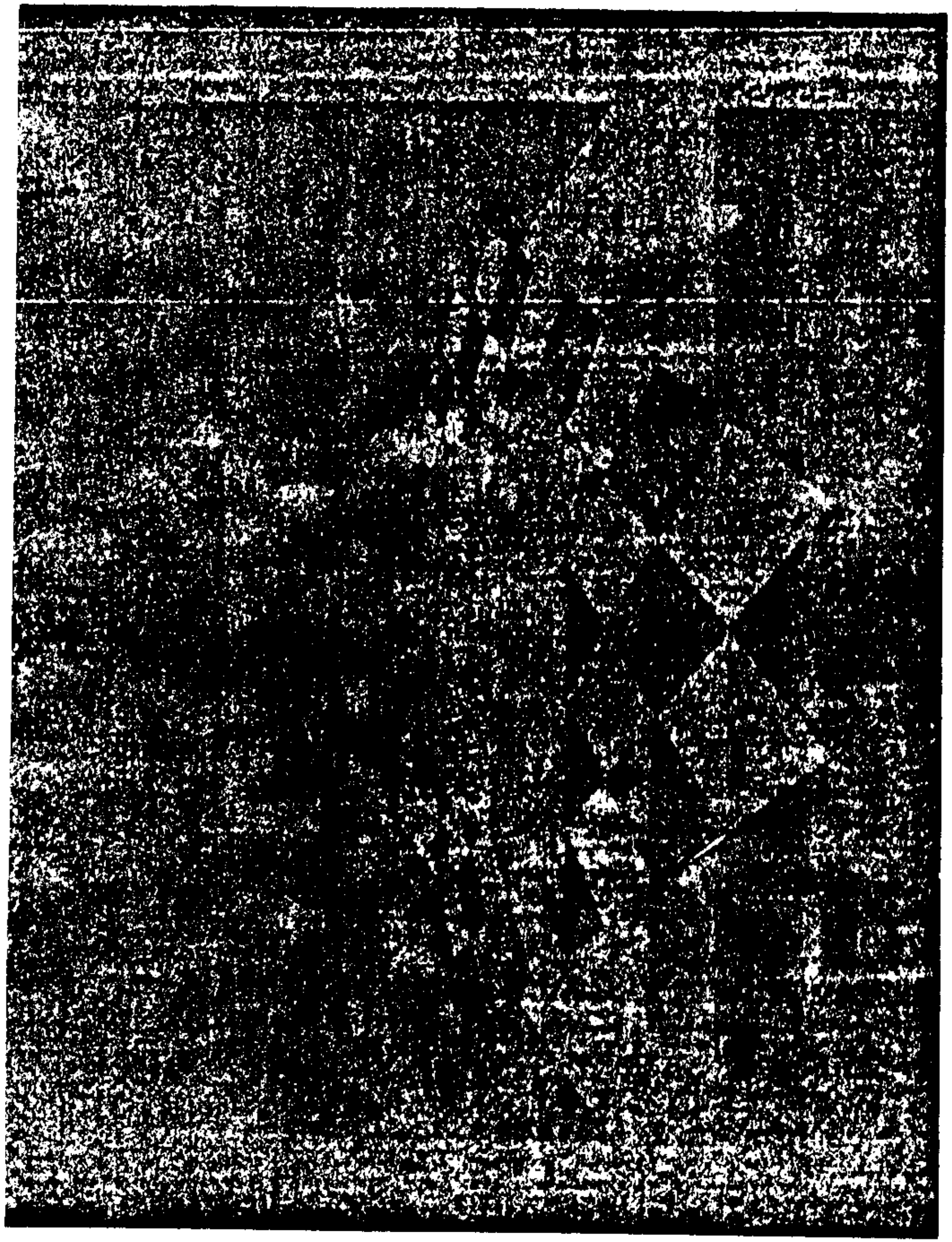
  direction of gaze (ground intersection)
- compute inverse perspective for known camera parameters
- compute optical flow with 1-dimensional VMA
- obstacles have different vector lenght
- obstacle height proportional to vector length

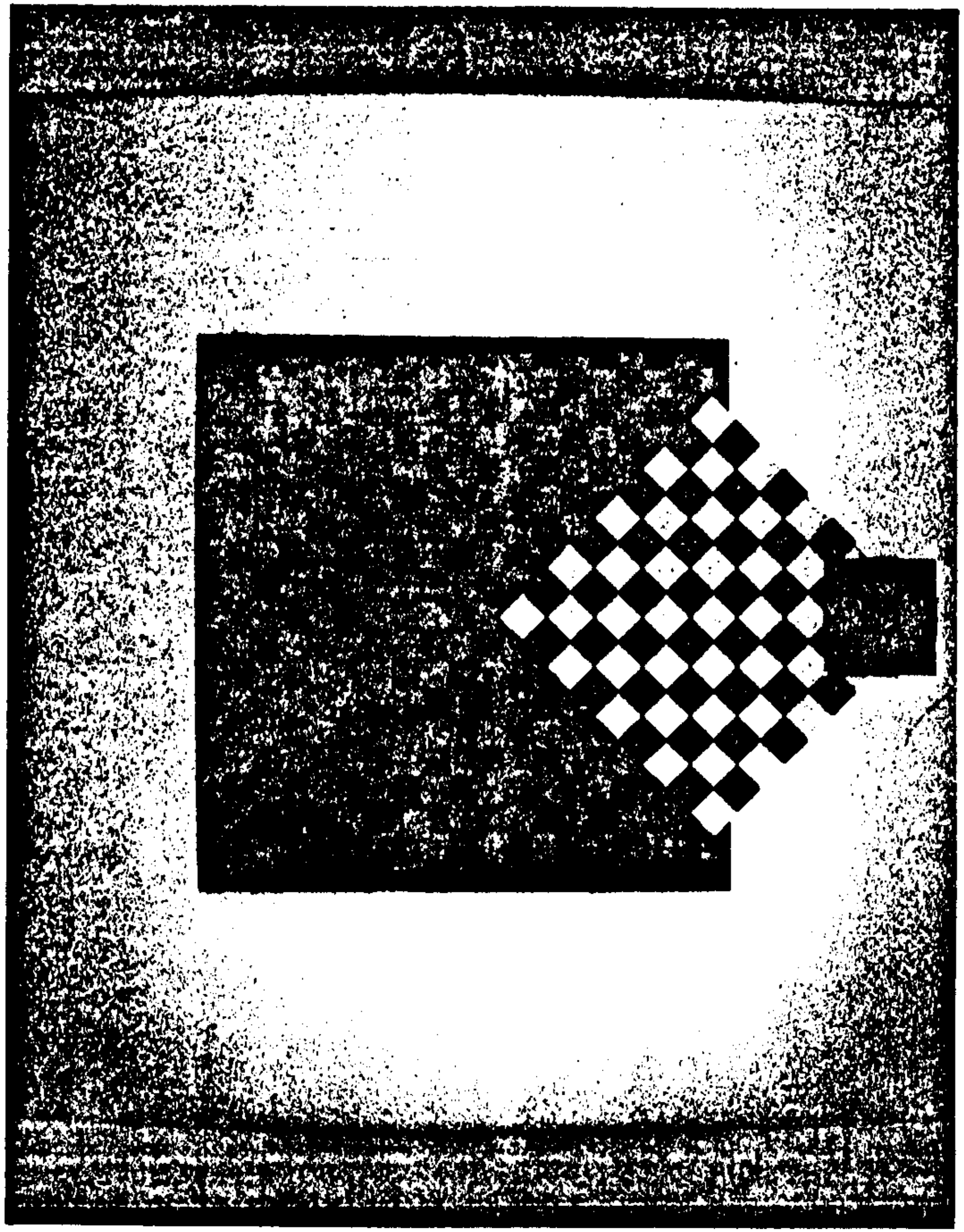
Conclusions

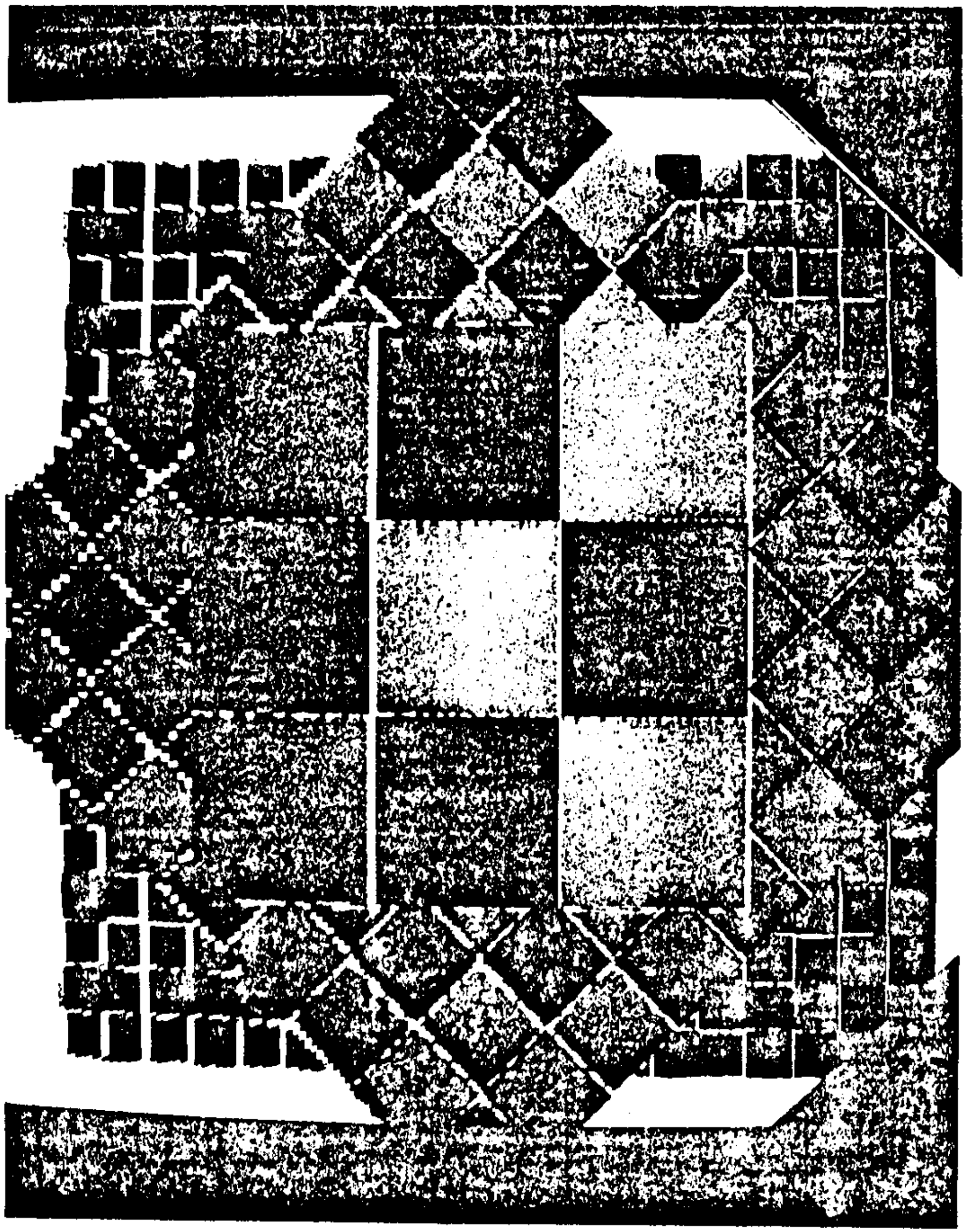
- inverse mapping speeds up motion computation
- especially suited for obstacle avoidence
- motion output scales with obstacle height
- works only for ground living animals or robots
- based on biological principles

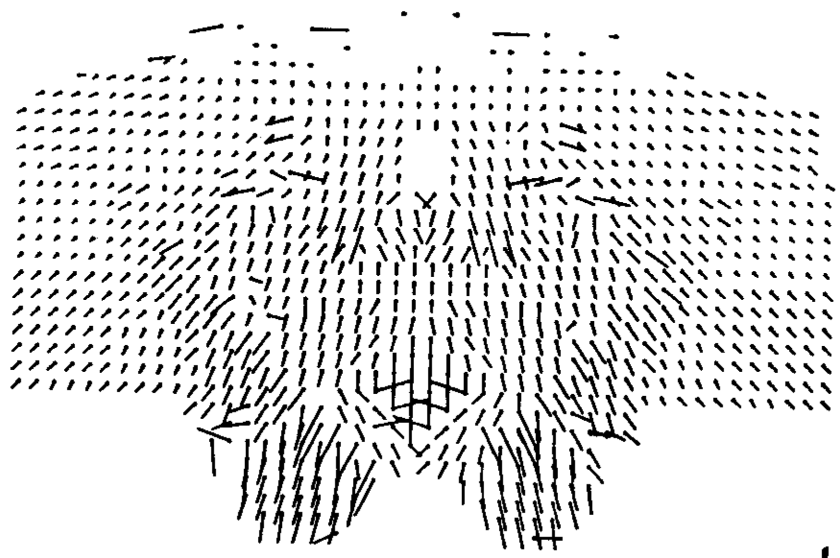
  cat ? monkeys?
- can be implemented on serial machines
- compute inverse perspective with optics,

  use view camera to tilt image plan
- fast, because non-iterative









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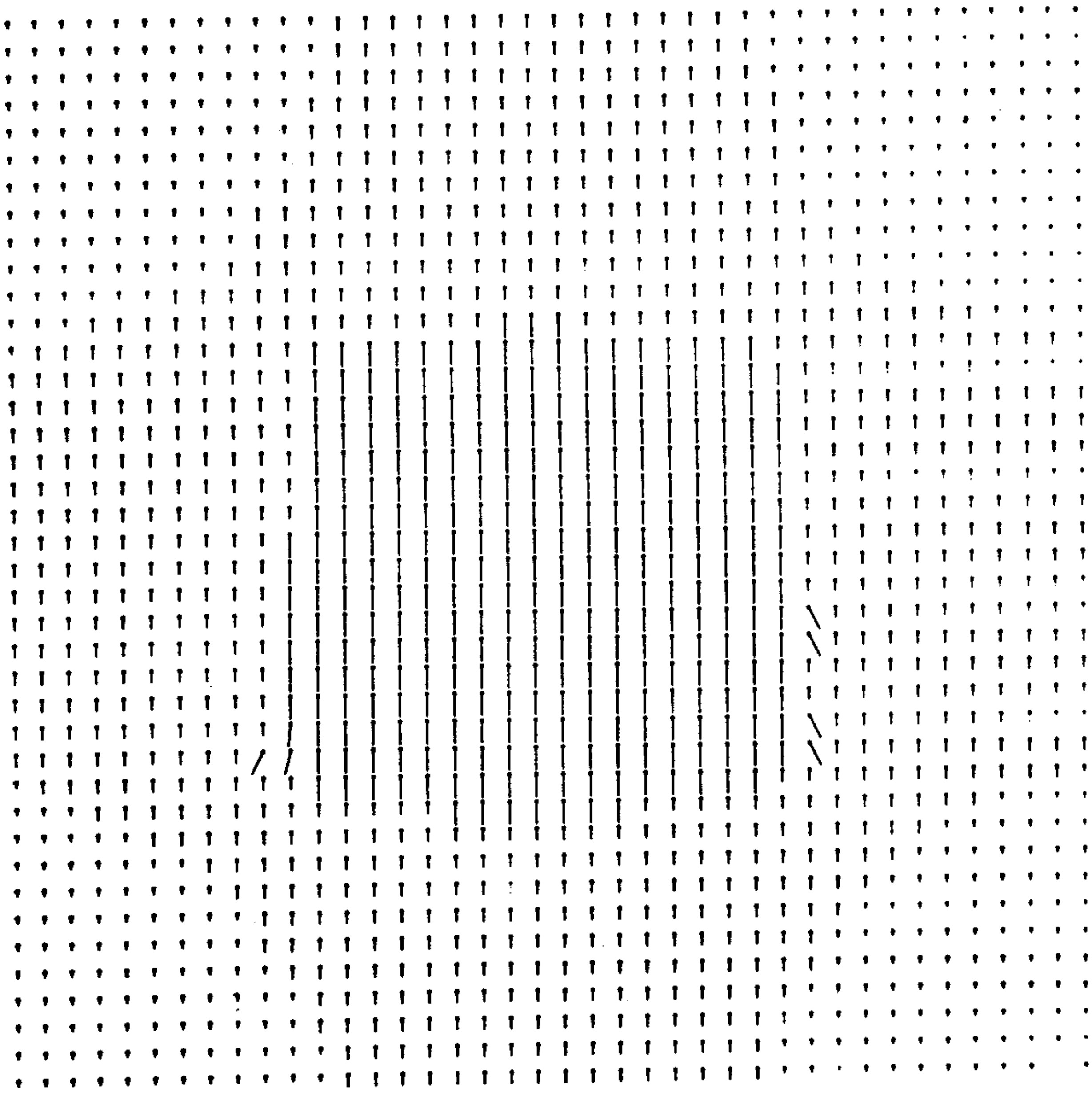

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