ROAD MONITORING & OBSTACLE DETECTION SYSTEM BY IMAGE ANALYSIS AND MATHEMATICAL MORPHOLOGY

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The Center of Mathematical Morphology (CMM) of the Paris School of Mines has been involved, with other french laboratories and car manufacturers PSA and RENAULT, in the design of a demonstrator, PROLAB2, in the scope of the european PROMETHEUS project.

CMM contribution

:

- Design of an on-board real-time image processor (MSM)
- Implementation of algorithms for:
  - Road and lane segmentation
  - Obstacle detection

ROAD AND LANE SEGMENTATION

Two different processes are used:

- Initialisation step
- Steady state

Common steps

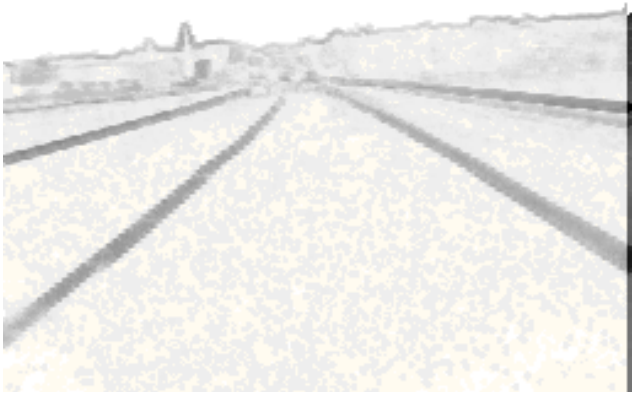
Morphological time filter based on temporal closings and openings.

→ Noise reduction

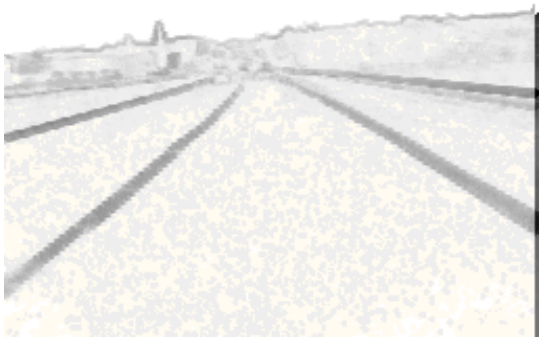
→ Closing of the discontinuous ground marking

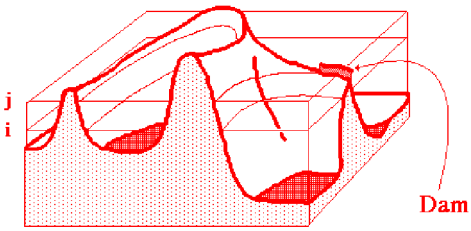
Morphological edge detector made of combination of:

- a morphological gradient
- a "Top Hat" transform

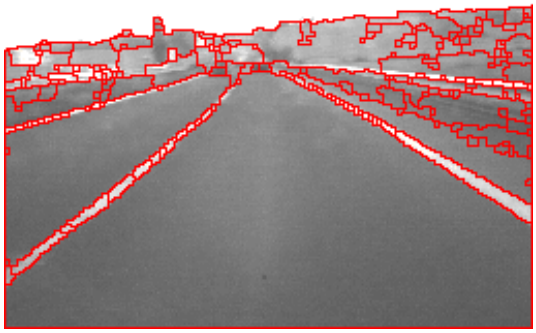


ROAD & LANE SEGMENTATION (continued)





A watershed transform is performed



Simple watershed followed by the extraction of the lane boundaries

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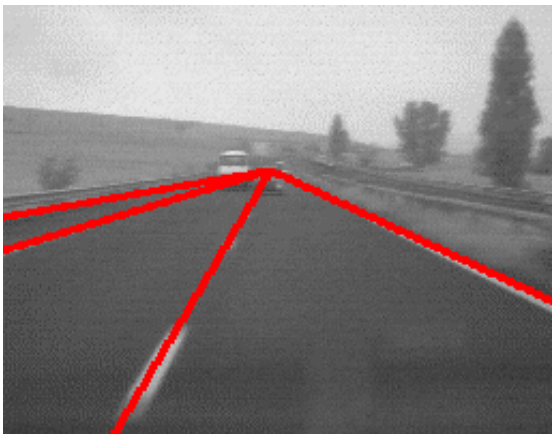
Road and lane model injected in the steady state segmentation by means of a marker-controlled watershed transform.



The lane model is used for segmenting the current image. The new segmentation allows to update the road model and therefore the marker used by the segmentation.

OBSTACLE DETECTION

Initialisation step

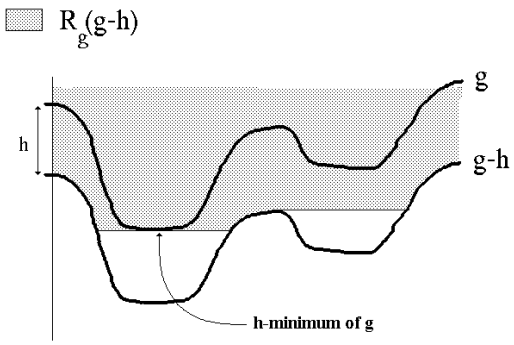
Steady state

The obstacle detection is performed in the region of interest (ROI) emphasized by the road segmentation.

Characteristics of an obstacle:

- Darker region in front of the vehicle
- Geometry (size) of the vehicle

The darker region is detected by means of a morphological transform called h-minima.



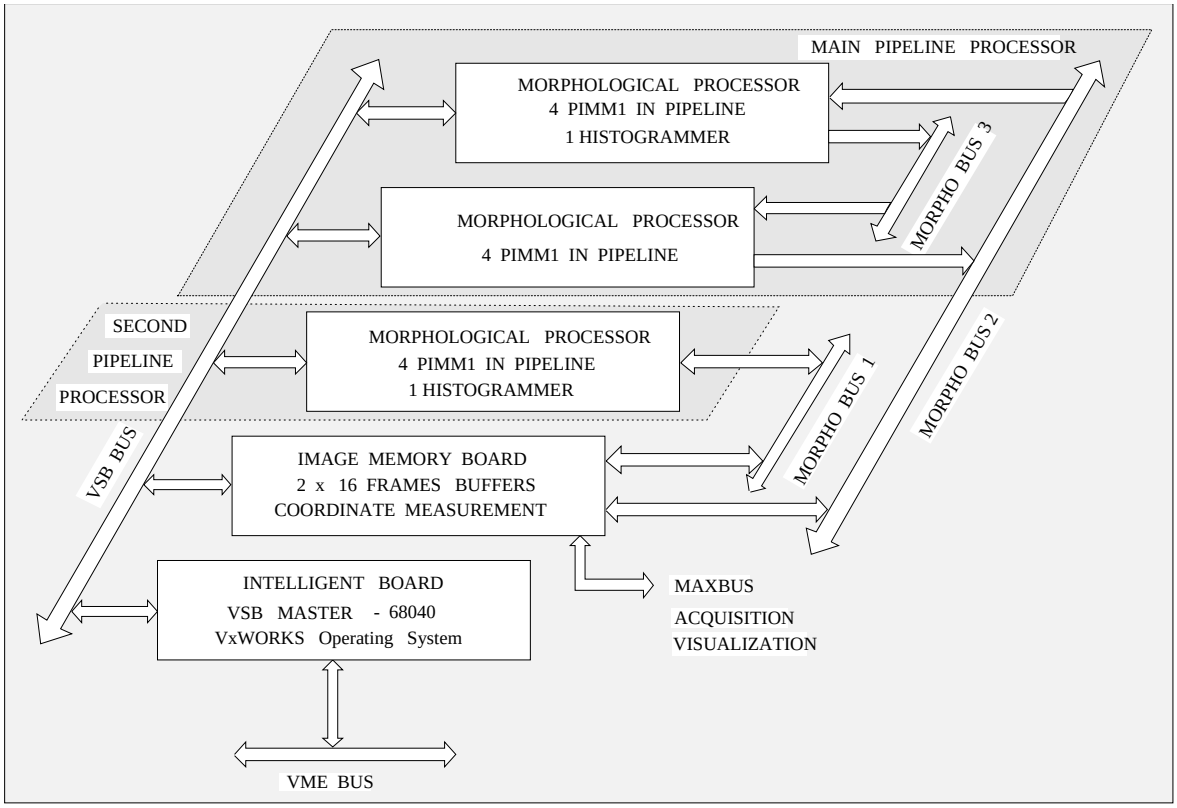
The possible markers are filtered and only those whose size corresponds to the dimension of a vehicle are kept.

A symmetry detector can be applied on the result.

- Symmetry

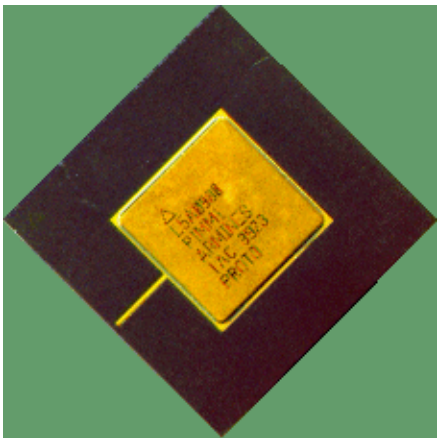
HARDWARE IMPLEMENTATION

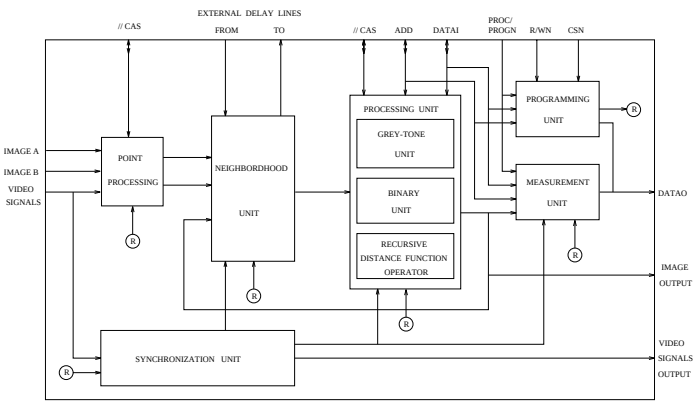
The real-time segmentation / obstacle detection is performed by a multi-pipeline processor (MSM).



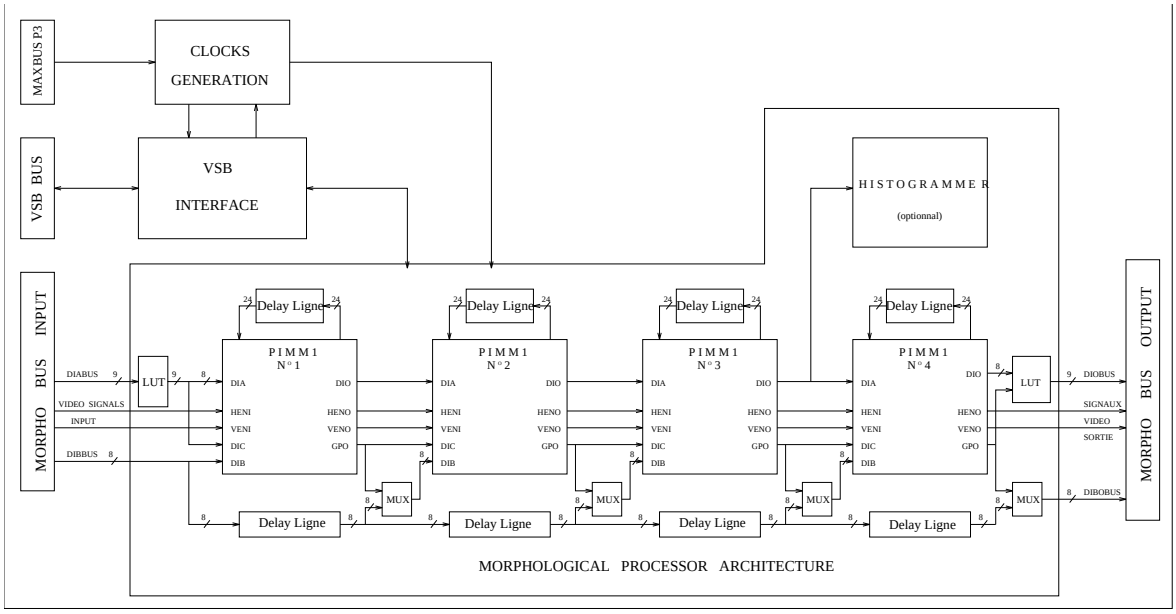
Multi- pipeline architecture

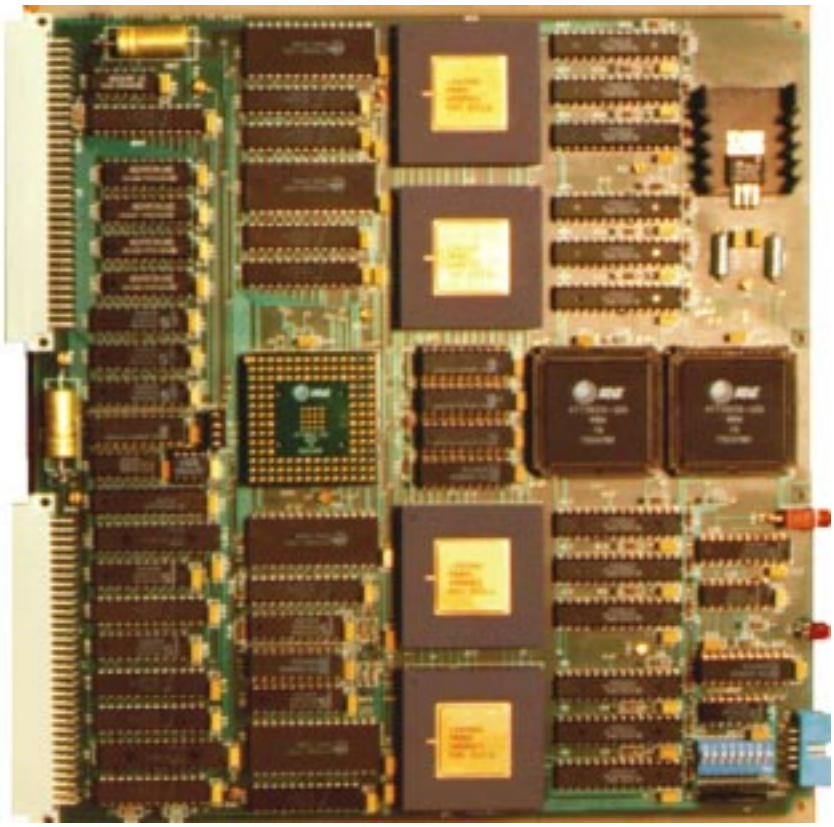
A morphological ASIC, PIMM1, is used for the design of the morphological processor board.





HARDWARE IMPLEMENTATION (Continued)





HARDWARE IMPLEMENTATION (Continued)

Two processors work in parallel:

- The first one made of two boards (8 PIMM1's) performs road and lane segmentations. Its a background task.

- The second one (1 board / 4 PIMM1's) is used for obstacle detection. This task is made on request by the supervisor.

These two processors share the same image memory.

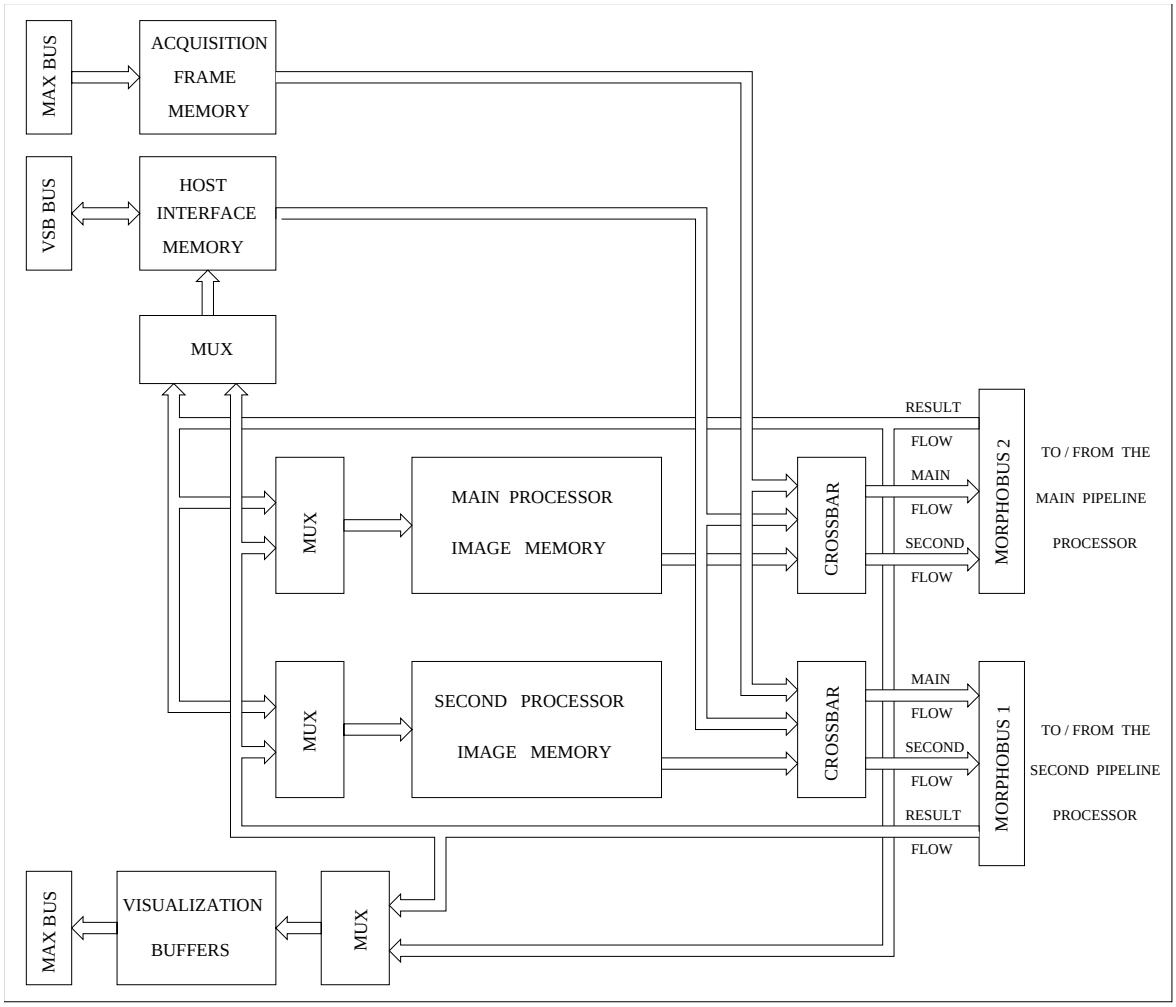
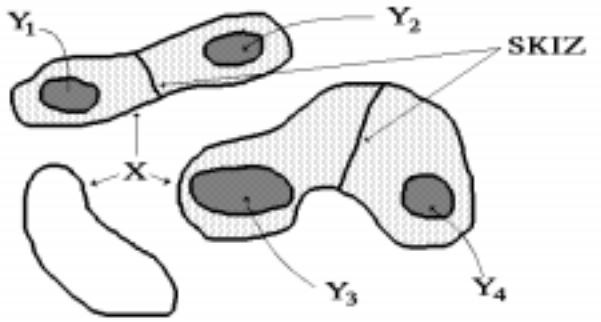


Image memory architecture

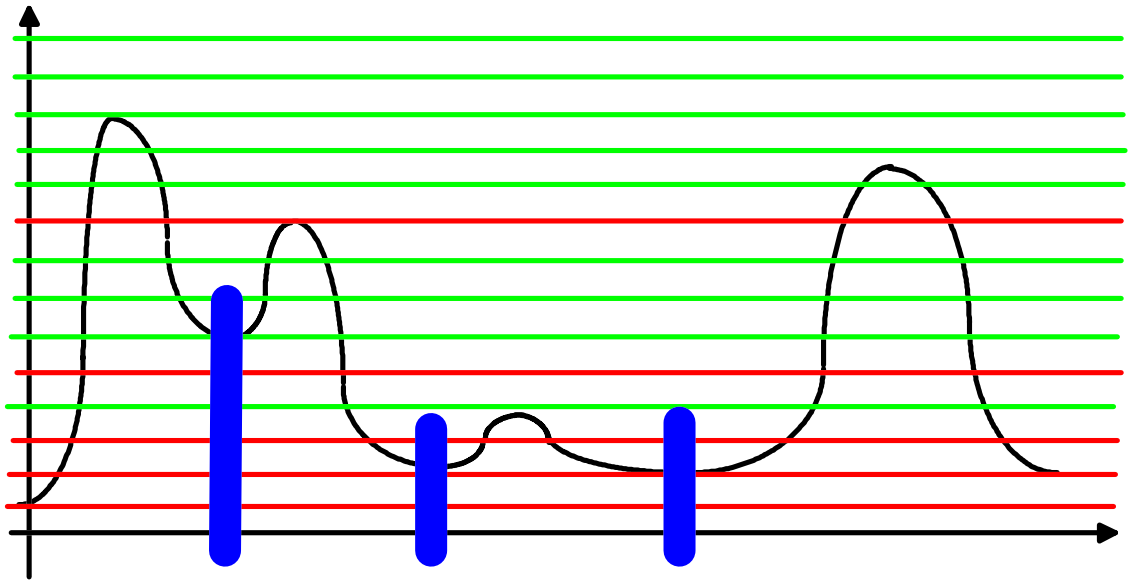
FAST WATERSHED ALGORITHM

The watershed transformation is performed by means of geodesic skeletons of influence (SKIZ).

This SKIZ is performed on each grey level of the function. Despite the fact that the processor is equipped with 8 PIMM1's, this transform is too slow.



In order to increase the computation speed, the number of processed grey levels is reduced by means of an anamorphosis.



Initial levels (in green)
Processed levels (in red)

The marker set is kept and used in the computation of the anamorphosed function

Log_2 anamorphosis → 8 grey levels instead of 256

PERFORMANCES AND DESIGN

- Watershed performed in 80 milliseconds on a 256x256x8 bits image
- Road segmentation and obstacle detection performed every 200 milliseconds (5 operations / sec)