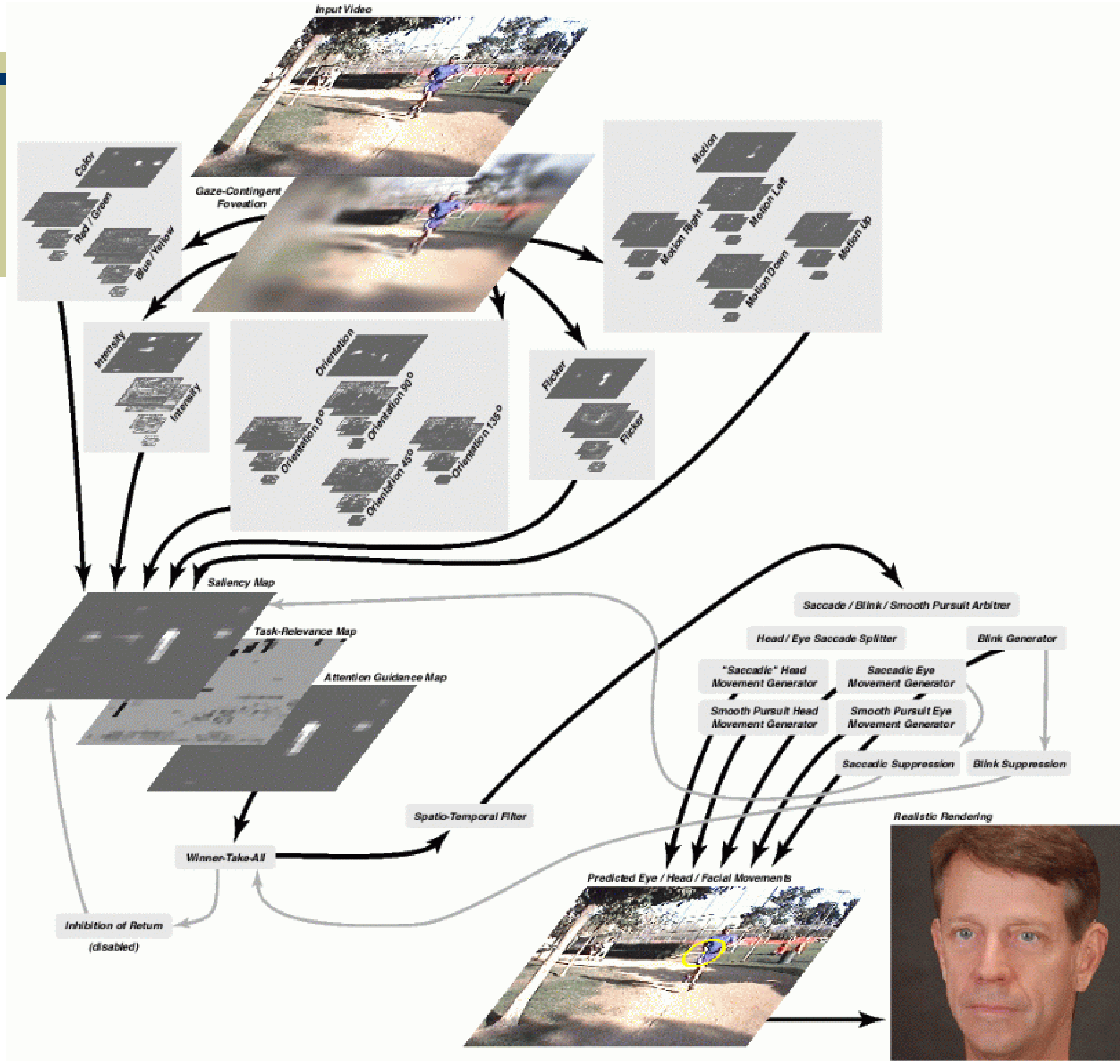
# Genetic Algorithms

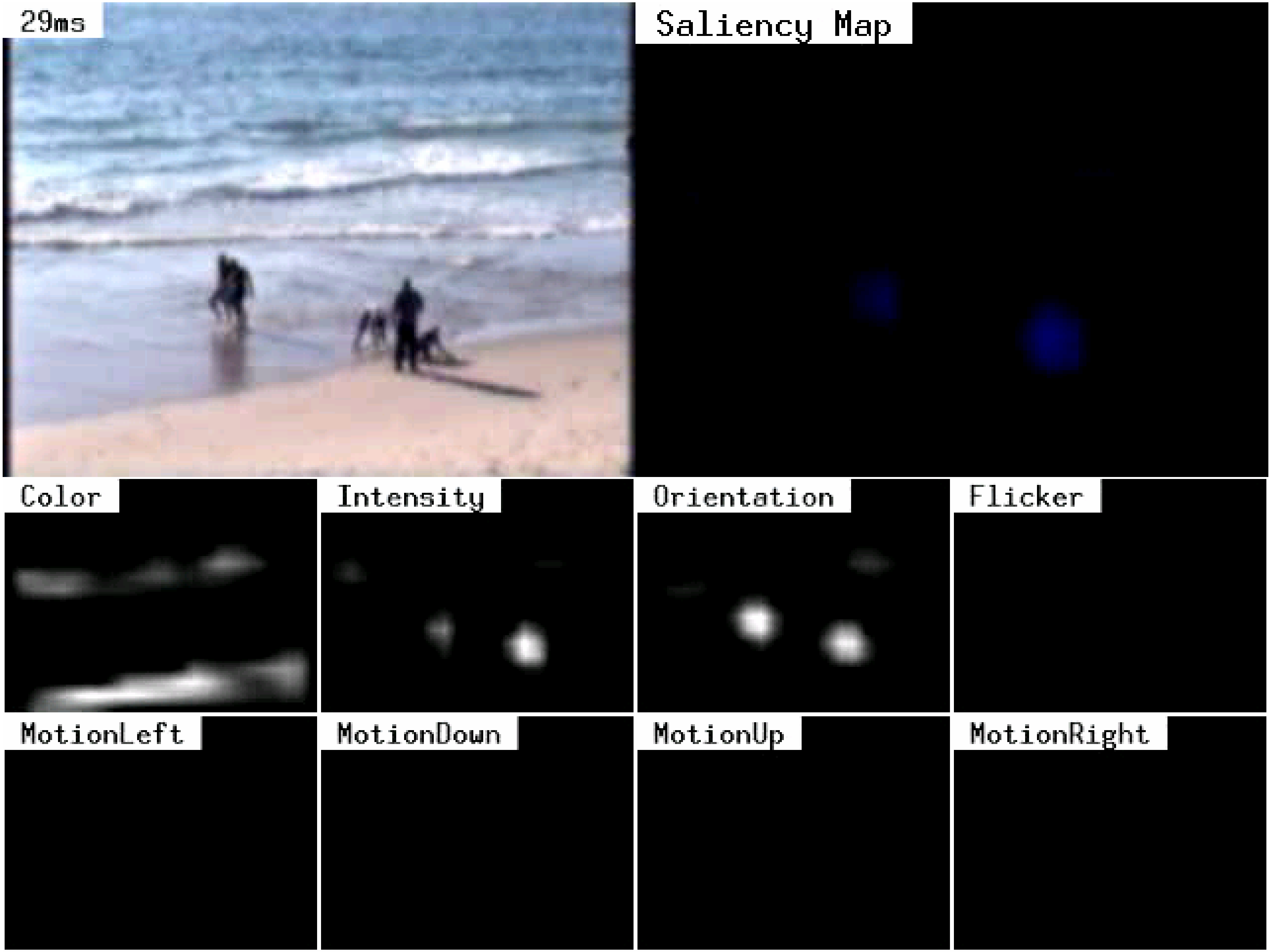
- An example real-world application



Input Video
Gaze-Contingent Foveation
Color
Red / Green
Blue / Yellow
Intensity
Intensity
Orientation
Orientation 0°
Orientation 90°
Orientation 45°
Orientation 135°
Flicker
Flicker
Motion
Motion Left
Motion Right
Motion Down
Motion Up
Saliency Map
Task-Relevance Map
Attention Guidance Map
Saccade / Blink / Smooth Pursuit Arbitrer
Head / Eye Saccade Splitter
Blink Generator
"Saccadic" Head Movement Generator
Saccadic Eye Movement Generator
Smooth Pursuit Head Movement Generator
Smooth Pursuit Eye Movement Generator
Saccadic Suppression
Blink Suppression
Spatio-Temporal Filter
Winner-Take-All
Inhibition of Return
(disabled)
Predicted Eye / Head / Facial Movements
Realistic Rendering

[redacted]

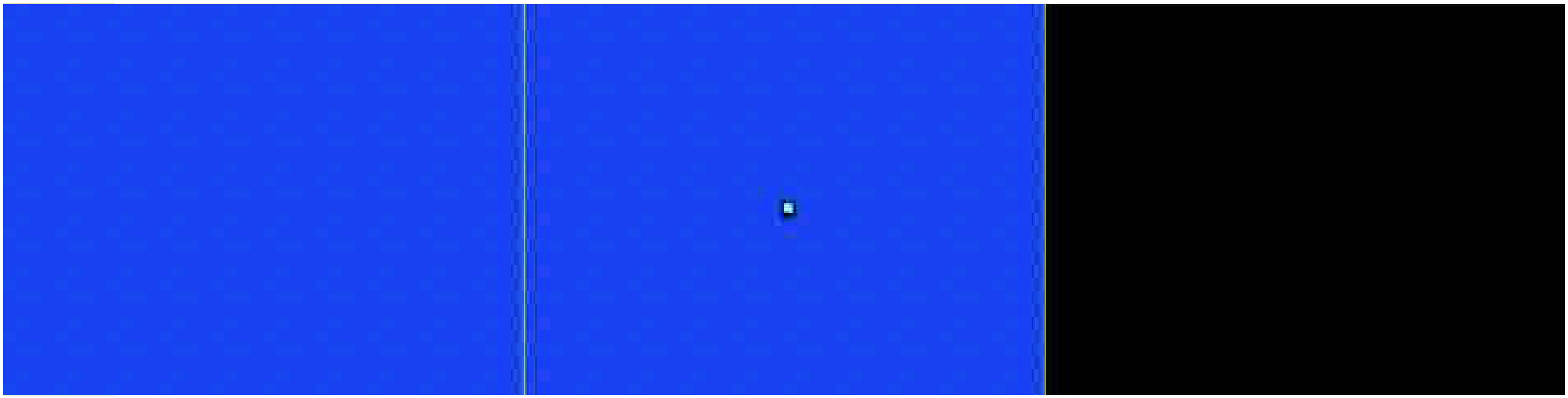
# Dynamic scenes



29ms
Saliency Map
Color
Intensity
Orientation
Flicker
MotionLeft
MotionDown
MotionUp
MotionRight


Saccadic Suppression
Saccadic Suppression

# Test stimulus



# Outdoors scene (easy)

# Outdoor scene (harder)

# TV ad


TOYOTA
TOYOTA

# Other outdoors

# TV news


3:05 AM ET
CNN Headline News
SANTA FE
SUNDAY
Can We Talk? New GA Gov invites
average citizens to 5-min chat sessions
NHL

# Questions

- This model uses hardcoded low-level visual feature detectors inspired from monkey and human brains
- Are these the best possible detectors?
- Why did our brains evolve in such a way?

# Training Filters to Detect Specific Salient Objects

Romain Bosa

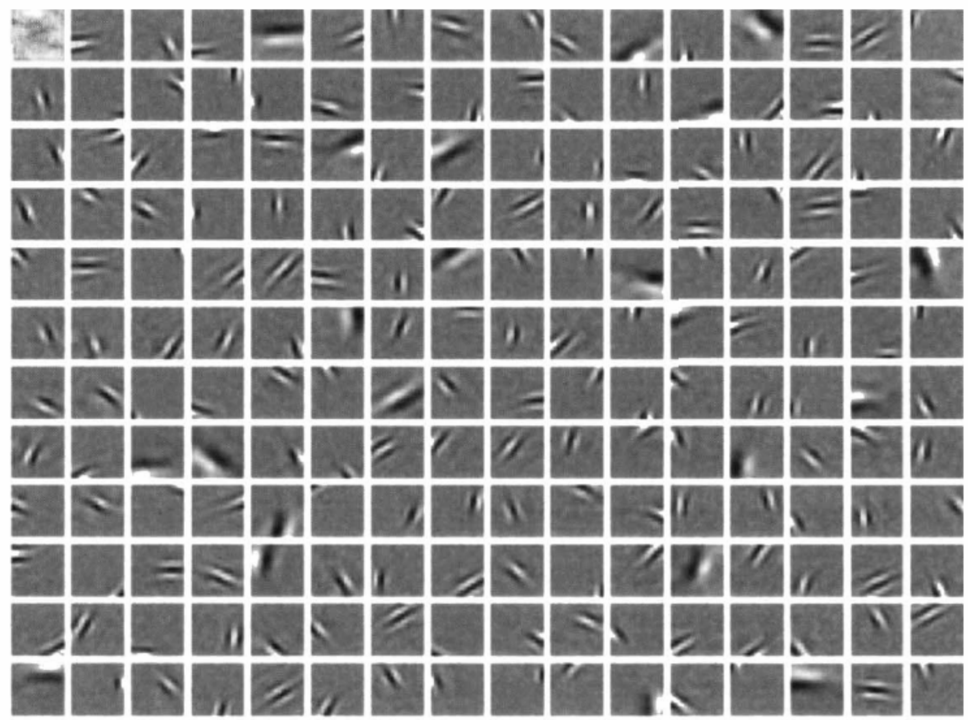
iLab

April – July 04

# Olshausen & Field, *Nature*, 1996

- Learning a sparse code for natural images
- Basis function similar to receptive fields
- Focus on picture reconstruction
- Can be adapt to detect specific targets

- E = – [preserve information] – k[sparseness]



# Our Work

- Training filters to specific target detection

  E = – [detection accuracy] – k[sparseness]

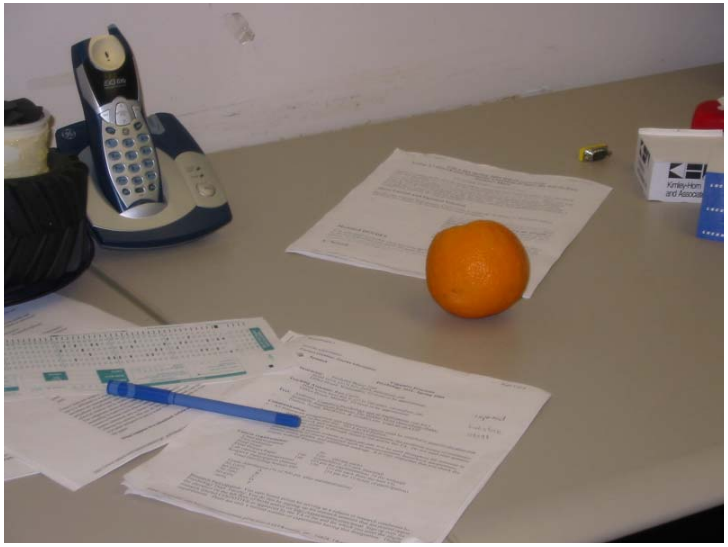
- Goals :
  - Automate specific target detection in natural pictures
  - Try to understand better the learning process of object detection in human beings
  - Use information on filters evolution during the training to be able to train analysts more efficiently

# Detecting Fruits

- First we tried to train filters in order to detect fruits (oranges and apples) in natural scenes
- Training of 3 RGB filters 8*8 (9 grayscale filters, 9*8*8=576 coefficients)
- Or, training on 3 greyscale filters 8*8 (3*8*8=192 coefficients)

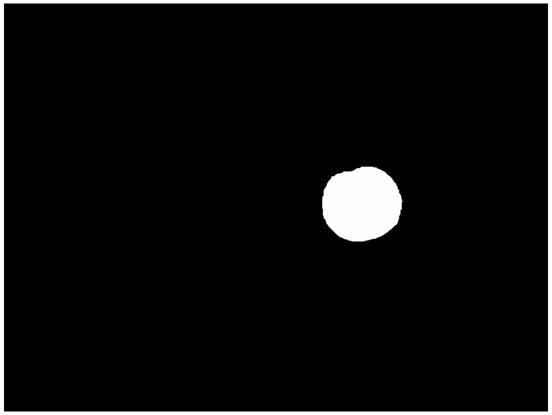
# The Data

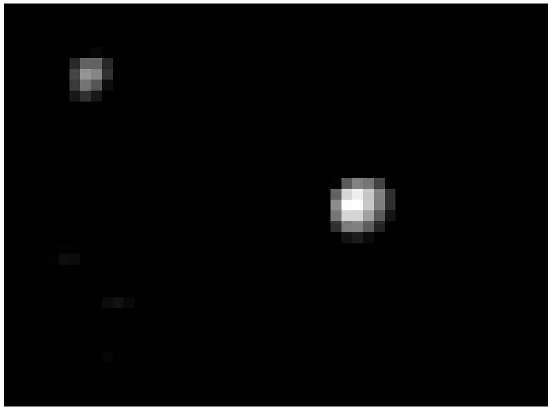
- Various pictures taken in iLab, and outside HNB
- The objects to detect in these pictures are fruits: oranges, red and green apples
- 14 pictures containing only one fruit are used for the training process



# The Score Function

- Object detection accuracy :
  - Manually-drawn binary mask (ideal saliency map)
  - (MaxSalOut – MaxSalIn) / 255 + 1

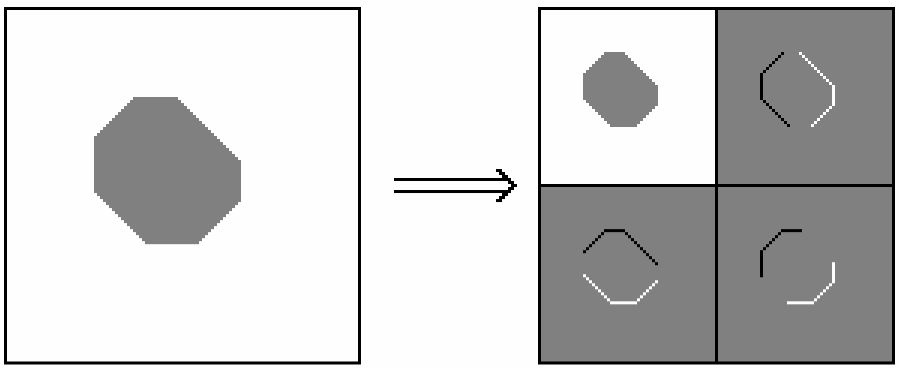




- Sparseness :
  - Dot products of the filters (absolute values)

# The Training Process

- A wavelet transformation (Haar) is applied to the filters to train more meaningful filters :



- Real function of 576 (or 192 for greyscale version) coefficients to minimize : the mean of the scores on each picture
- The method used is a genetic algorithm
- Filters are initialized with random values

# Genetic Algorithm

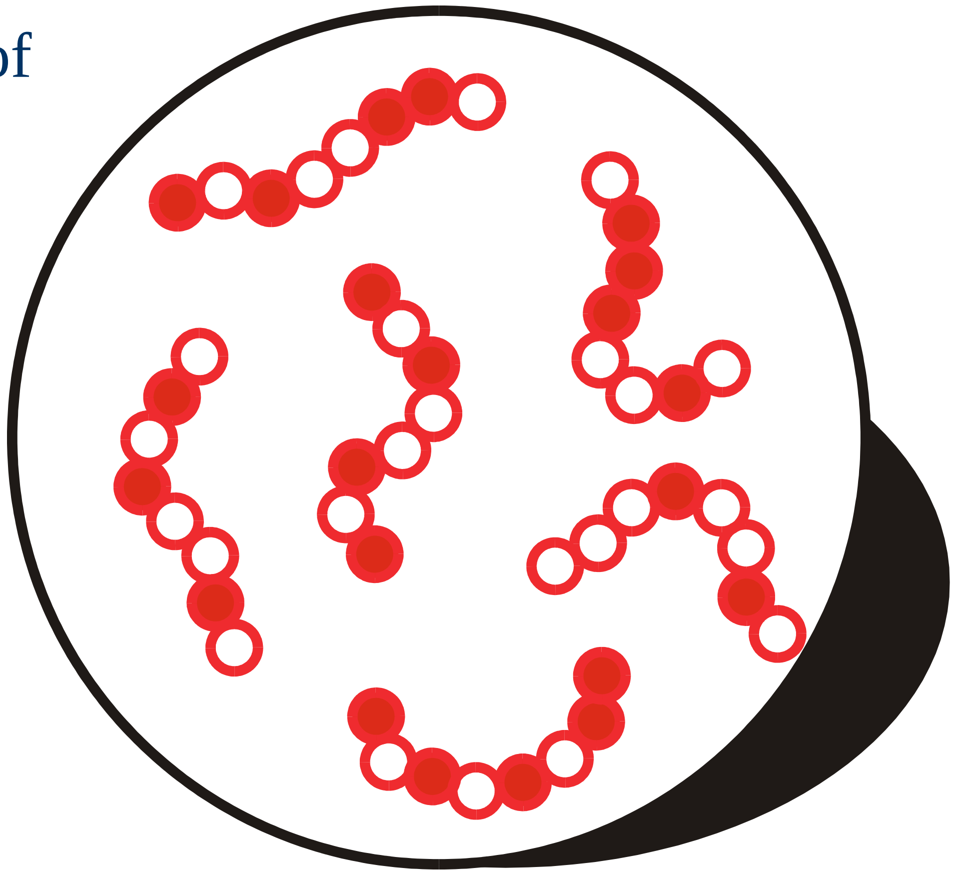
- Reduce number of possible filters by allowing each wavelet coefficient to only be -1, 0 or 1
- **Chromosomes:** sequences of 576 (color) or 192 (greyscale) numbers, e.g.:

  -1, 0, 0, 1, 1, -1, -1, 1, 0, … , 0, 1
- **Mutations:** randomly change some value in the chromosome into another value
- **Crossovers:** create two children by exchanging some of the genes from two parents

# A “Population”

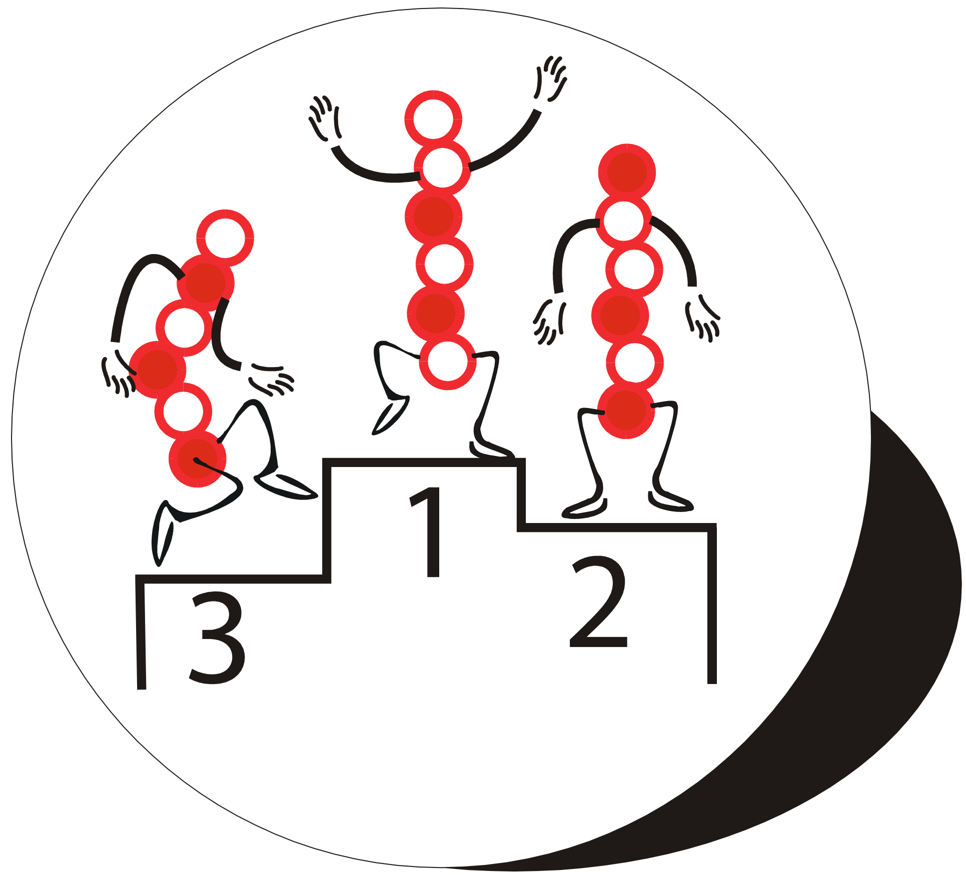
**Chromosomes:** sequences of 576 or 192 numbers, e.g.:
-1, 0, 0, 1, -1, 1, 0, … , 0, 1

**Population:** start with 200 “individuals” initialized with random chromosomes

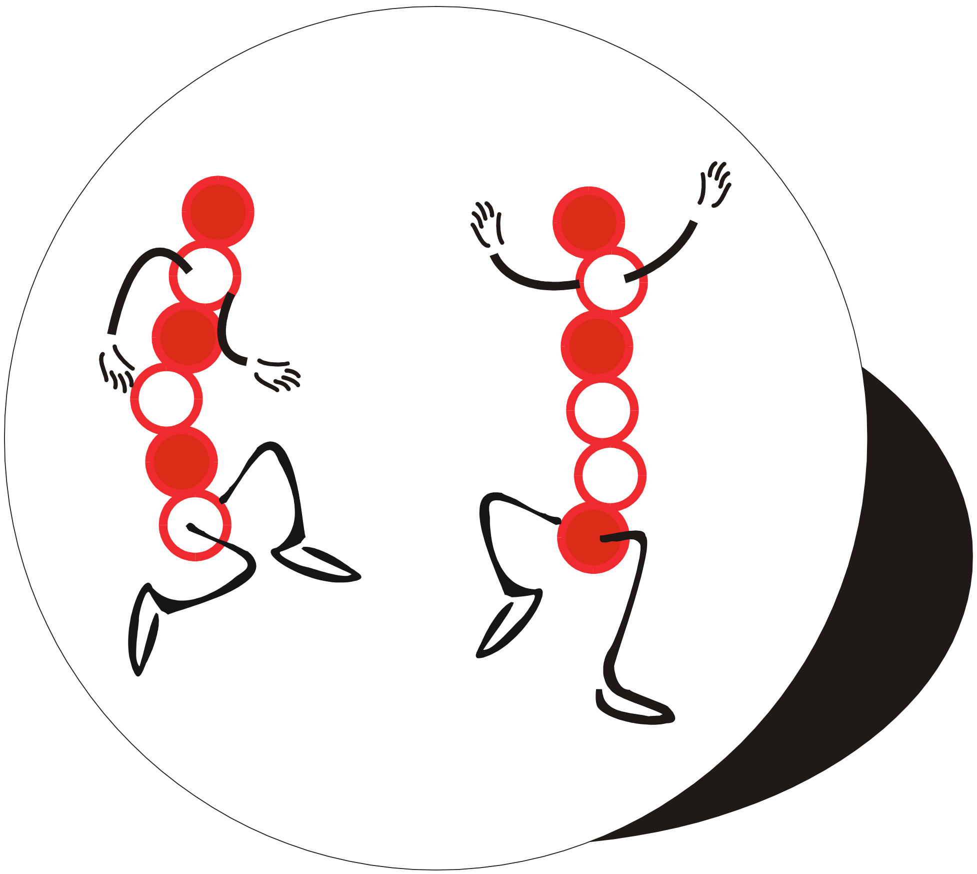


# Ranking by Fitness:

**For each individual:** compute saliency map using the filters from that individual's chromosomes, and measure how salient the fruits of interest are. Repeat over all training images and compute average score. This is the "fitness" of that individual.

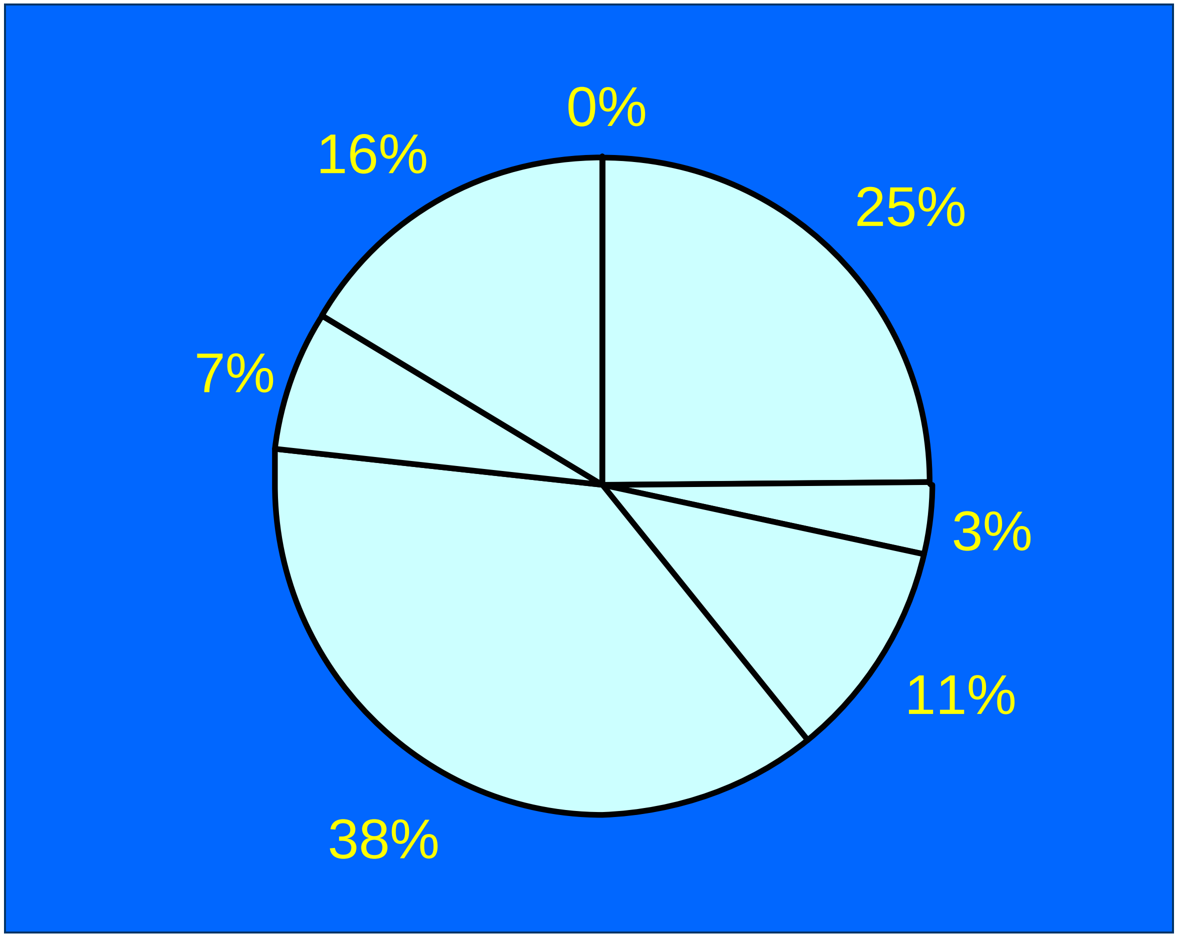


# Mate Selection:
# Fittest are copied and replace less-fit

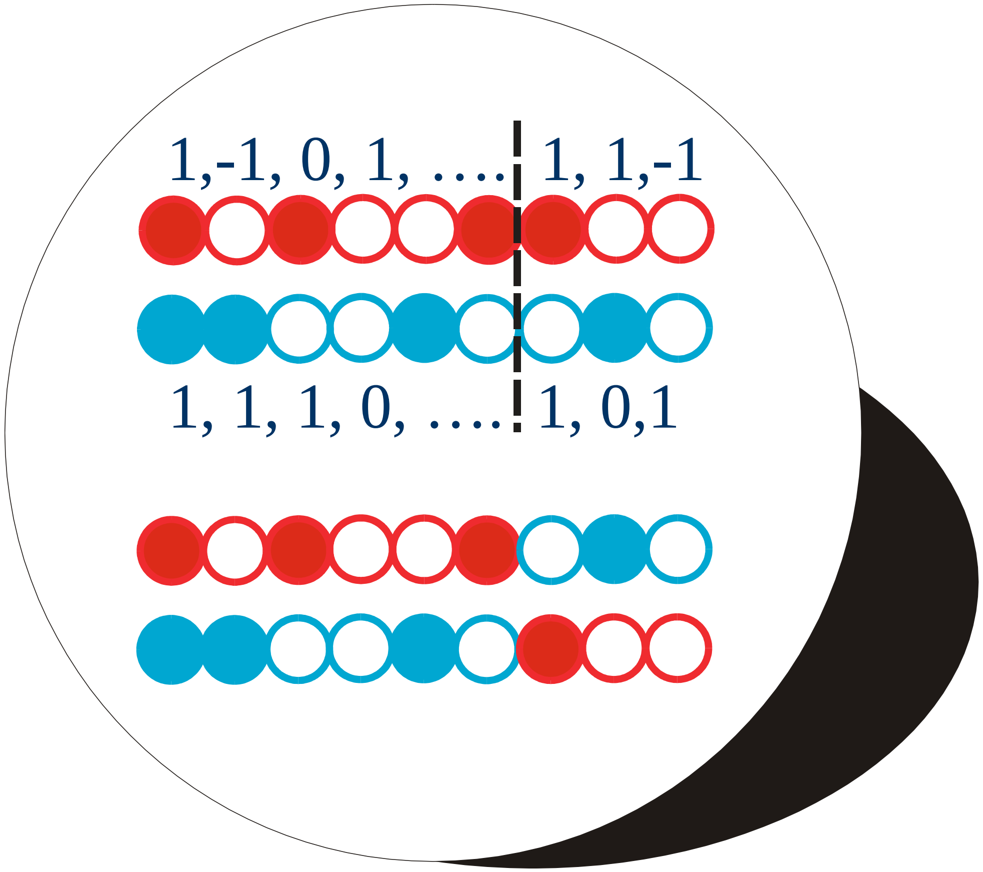


# Mate Selection Roulette:
## **Increasing the likelihood but not guaranteeing the fittest reproduction**

Create N children from N parents (population size remains constant)



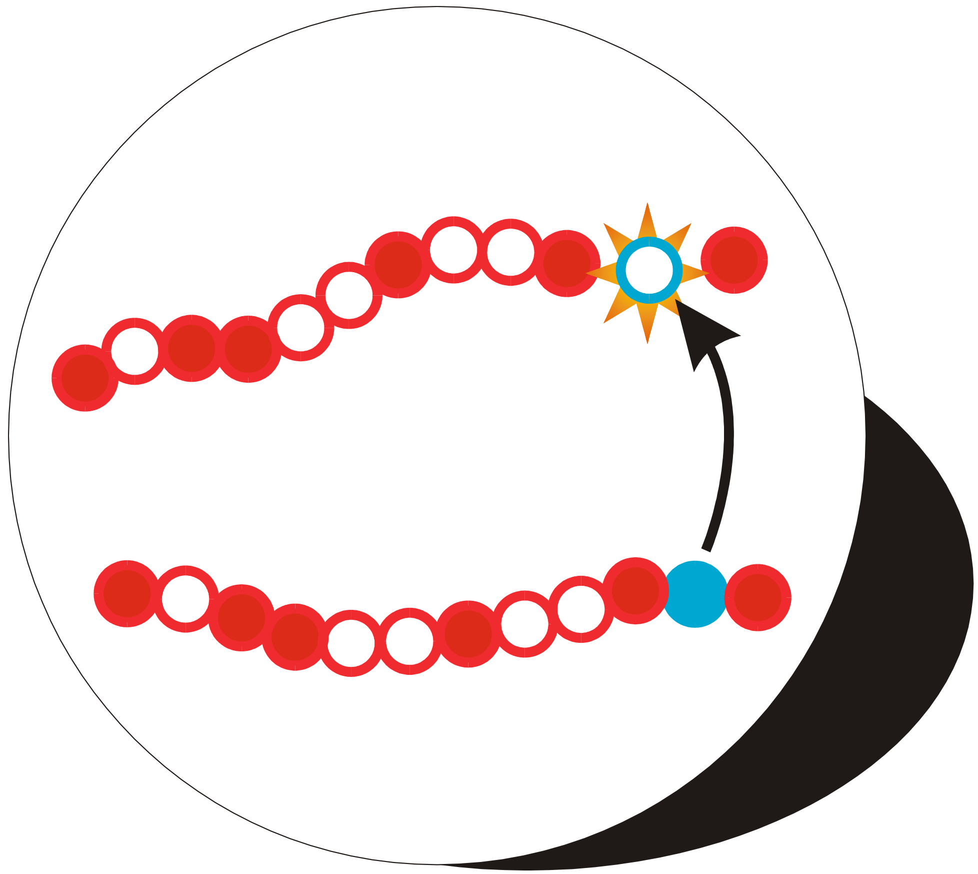
# Crossover:
## Exchanging information through some part of information (representation)



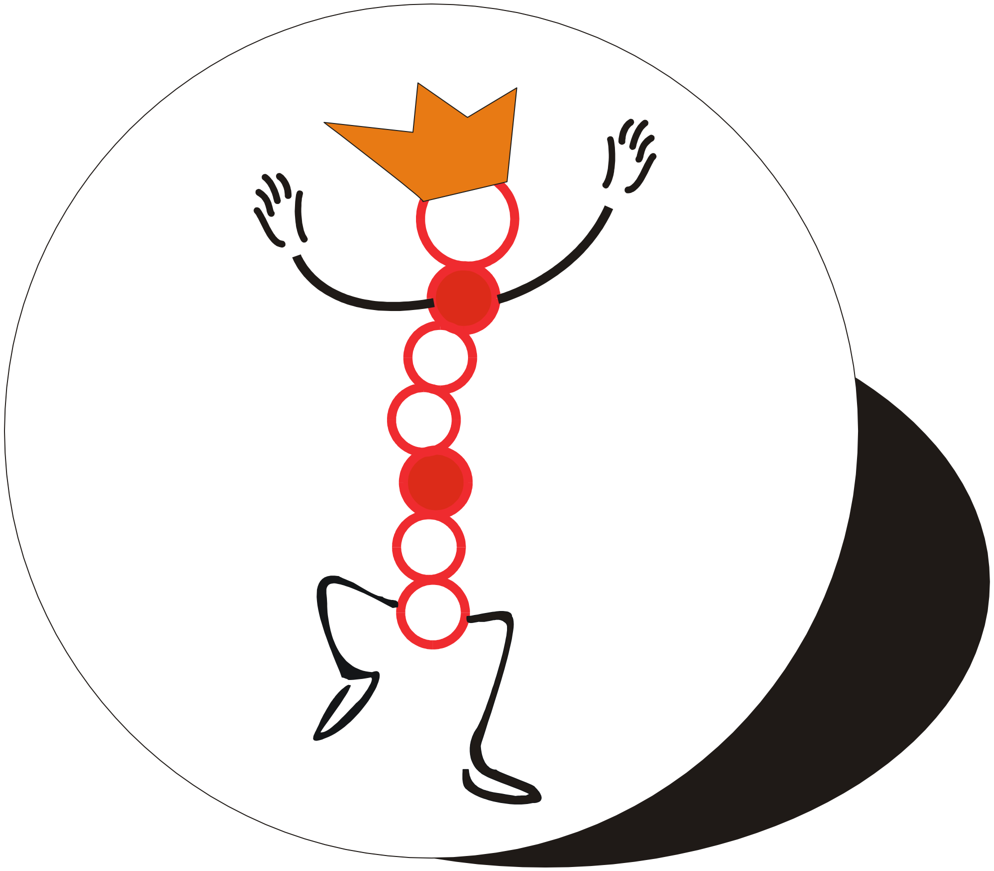
# Mutation:

## Random change of binary digits from 0 to 1 and vice versa (to avoid local minima)

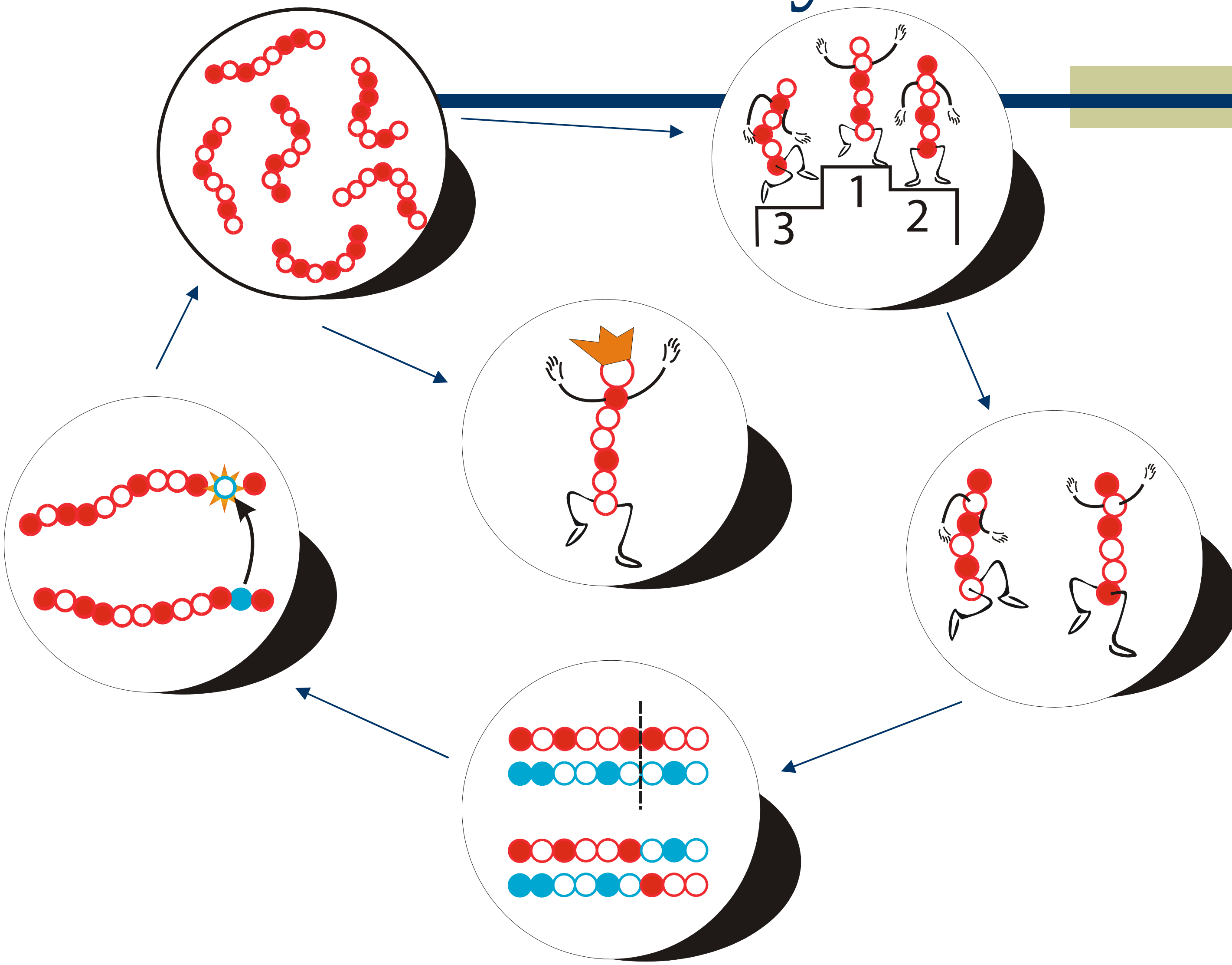
In our case,
Random change to
-1, 0 or 1



# Best Design

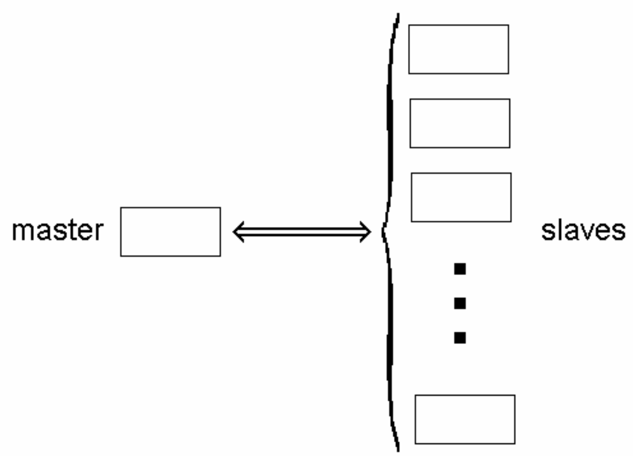


# The GA Cycle

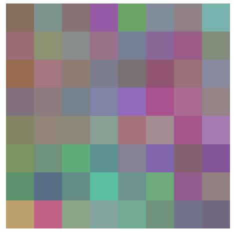
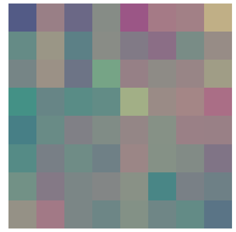
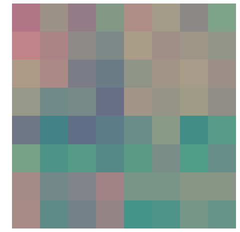


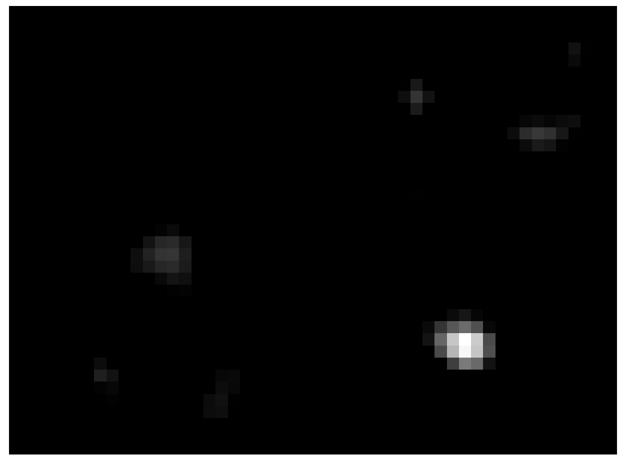
# Computation on HPCC cluster

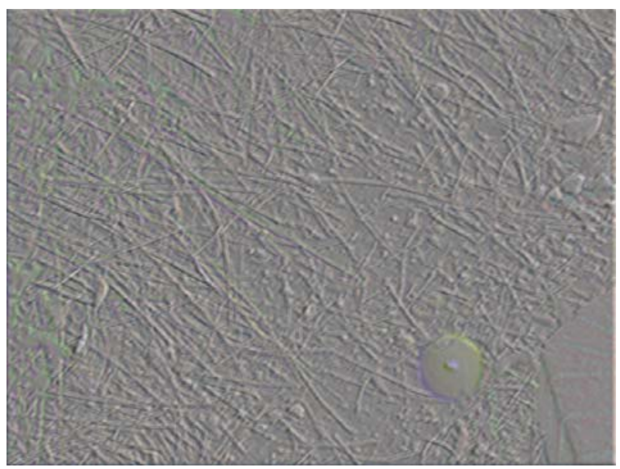
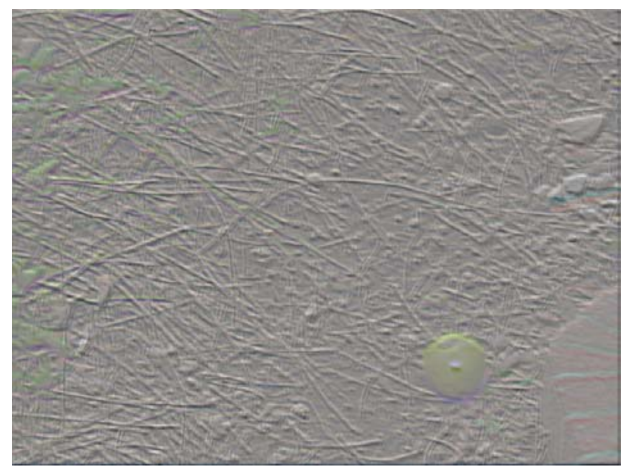
- 193 nodes (CPUs)
- 1 “master” node which keeps filters and score function up to date
- 192 “slaves” nodes which handle score evaluation




- MPI protocol is used for communications between nodes



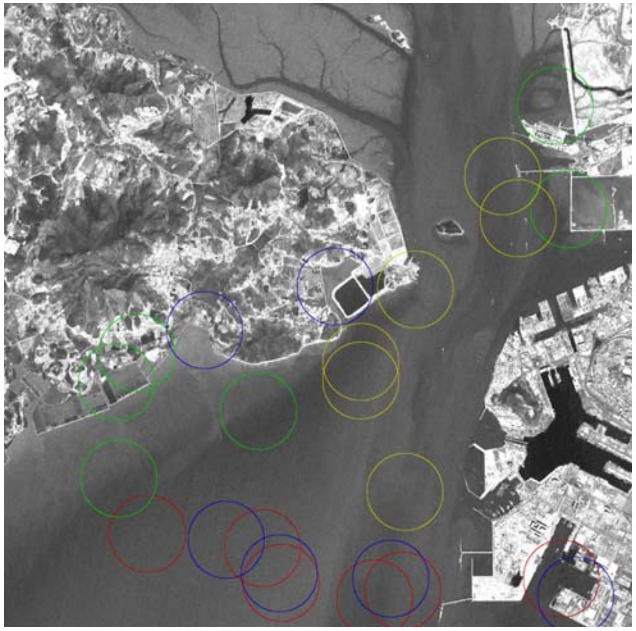



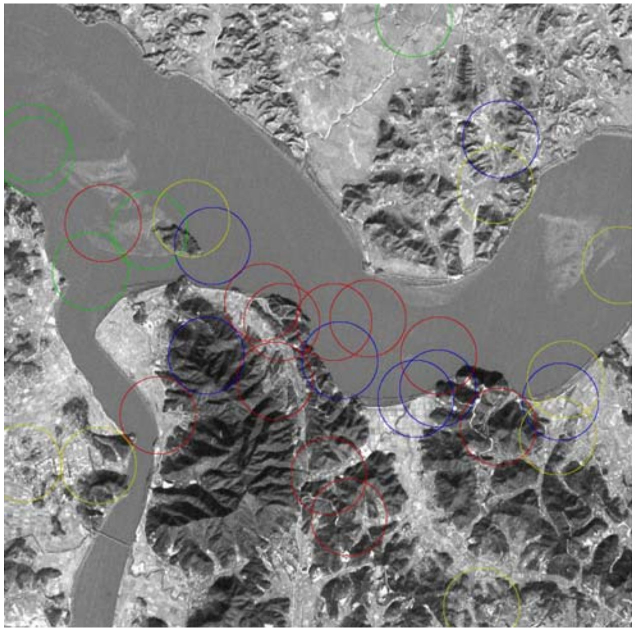
# Detecting Interesting Targets

- Instead of trying to detect specific targets, we are now trying to detect targets of interest in satellite pictures
- Training of 3 grayscale filters 8*8
- Same training process used
- New score function

# The Data

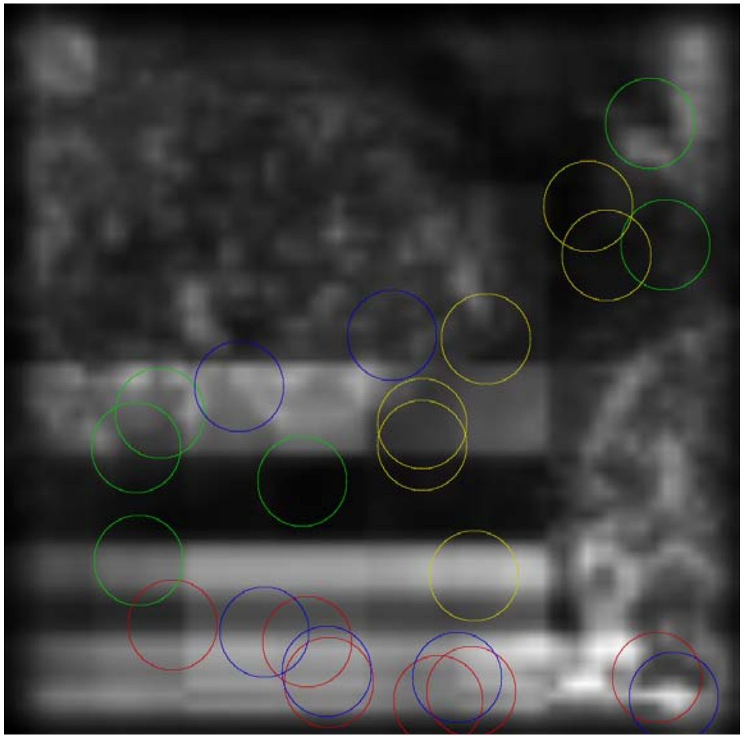
- Satellite pictures with records of 4 subjects' eye-movements (Rob's data)
- 10 pictures are used for the training process
- The aim is to get a saliency map matching the eye-movement (in particular the end of eye saccade locations)

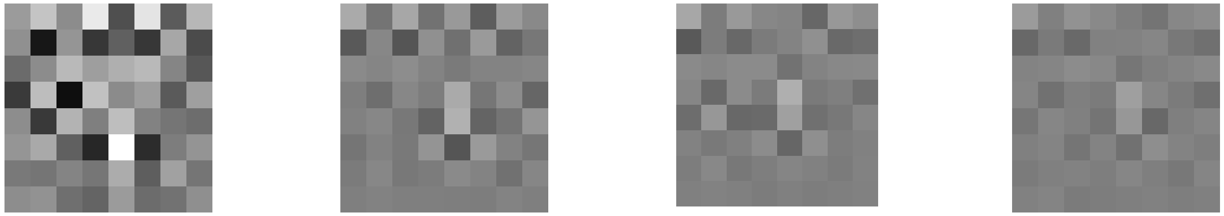


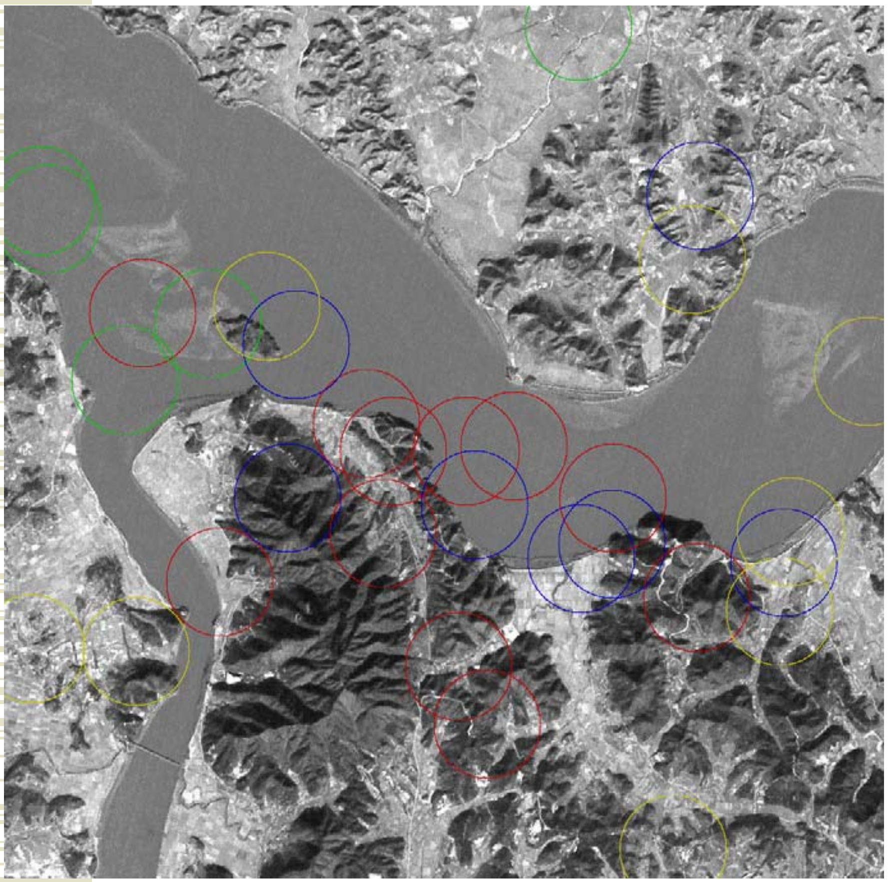


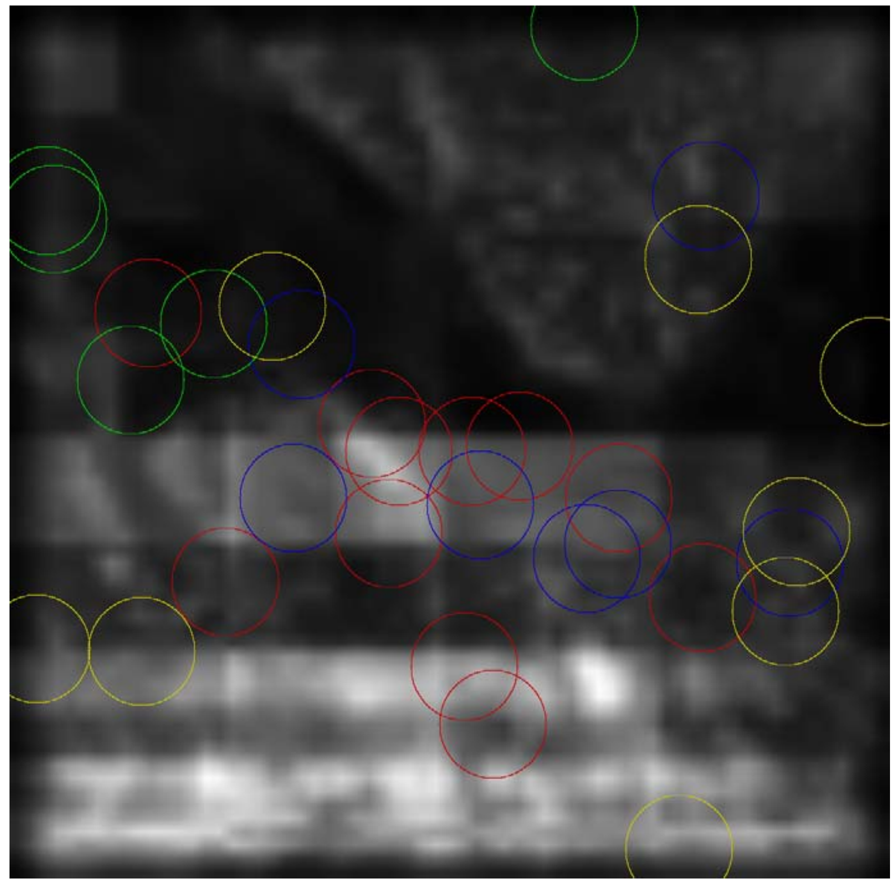
# The Score Function

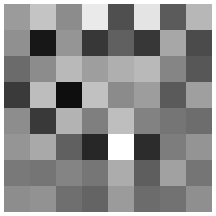
- Detection accuracy :
  - Samples around end of saccades locations
  - $S_i$ = max saliency in sample #i
  - $S = \text{mean}(S_i)$
  - A = average saliency on the map
  - Accuracy score = (A + 1) / (S + 1)
- The sparseness score doesn't change

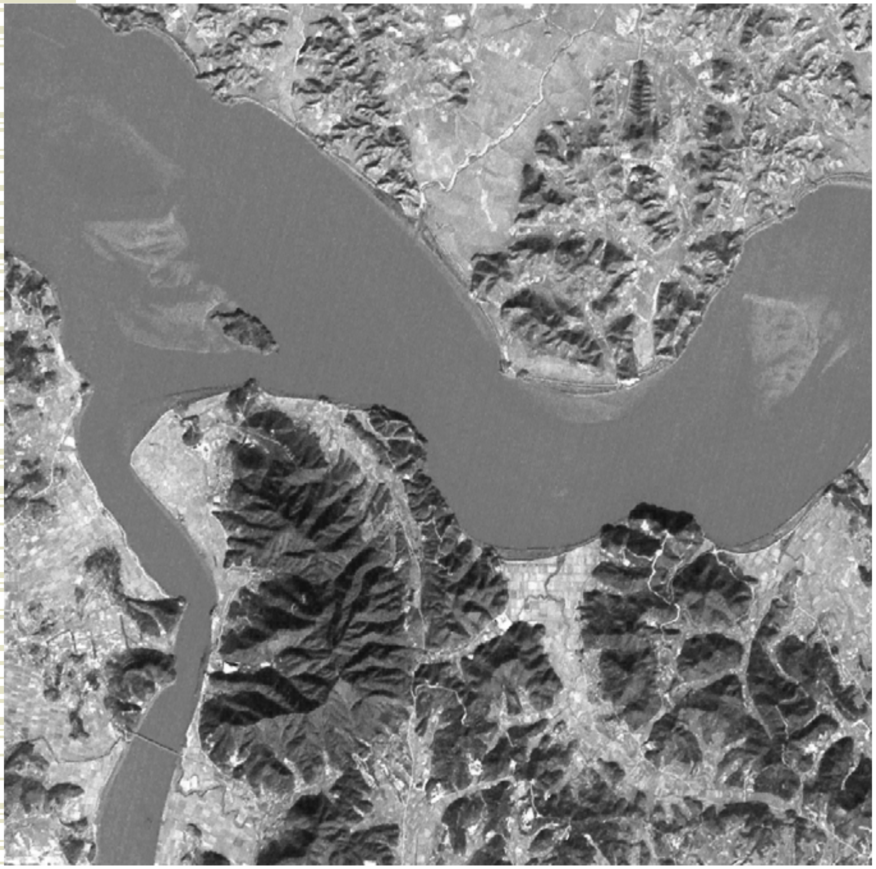








# Convolution by 



# Conclusion

- The work is still in progress, but the training process seems to work better with the eye movement score than with the fruits detection.
- The next step will be to train more filters, in order to get more accurate results.
- This work can be really interesting in terms of satellite images analysis, because if we managed to train accurate filters, we would have an automatic and very efficient way to find interesting locations, as a human being would.