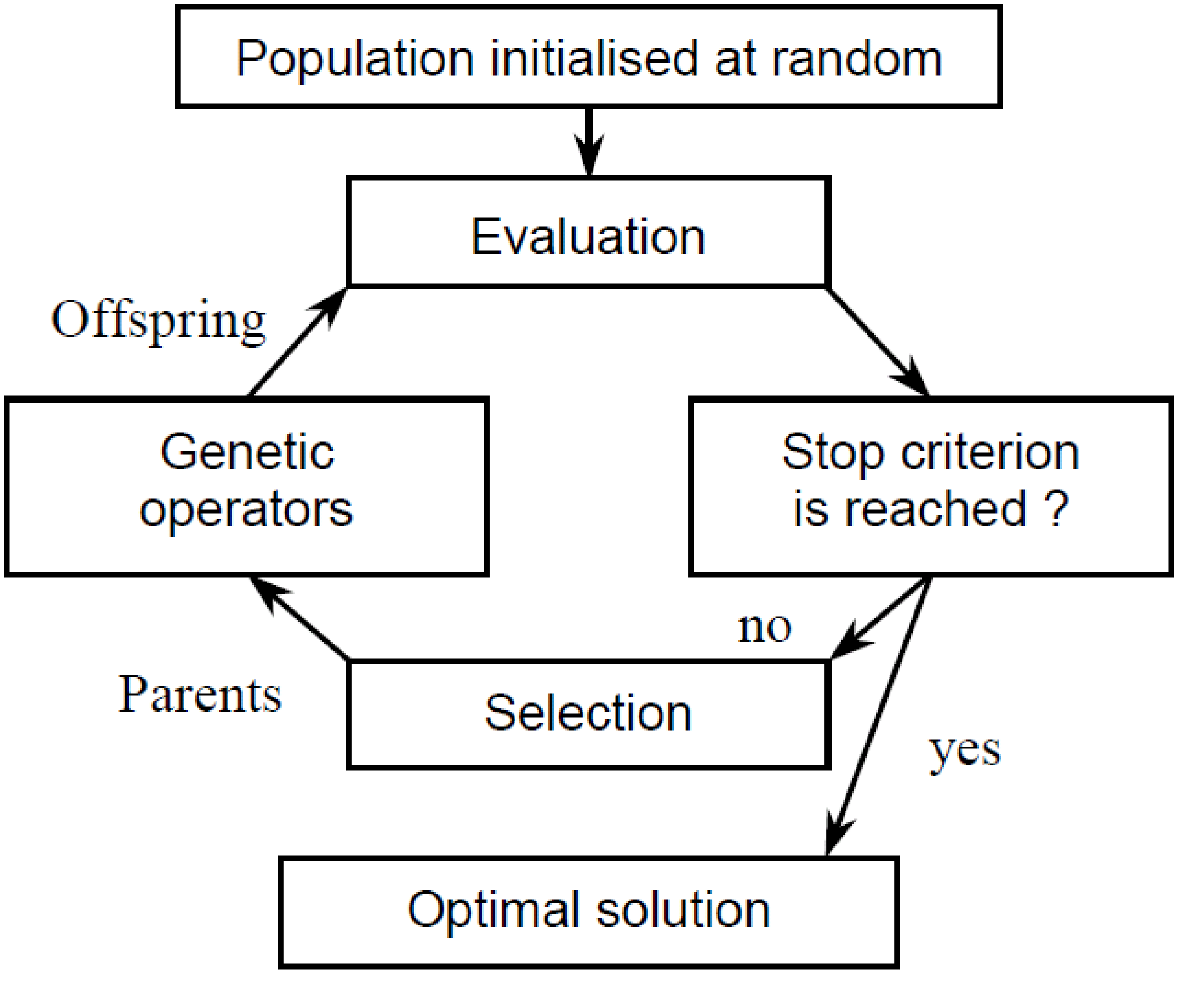
Algoritmy pre AI robotiku, VI. Diel

fly algorithm, CMAES

Pavel Petrovič
ppetrovic@acm.org

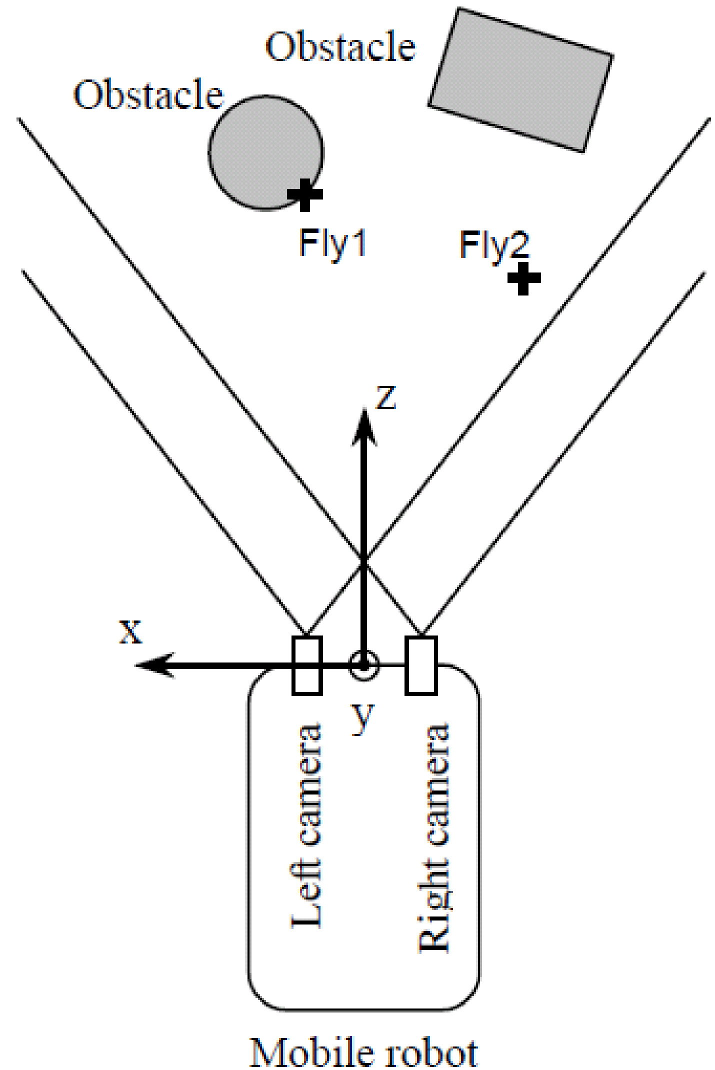
General framework of EA



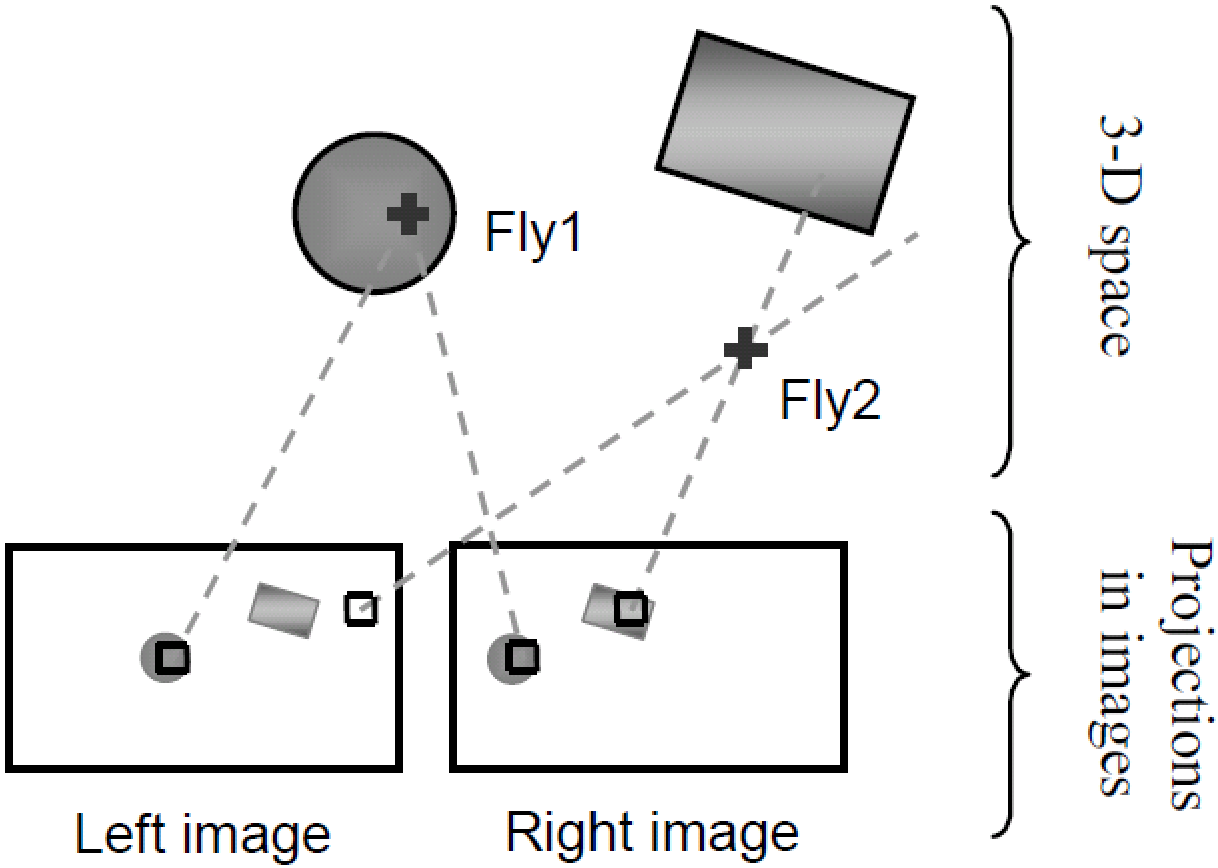
General framework of EA

- the population is a group of individuals
- an individual is defined by his genes $X = (x_1, x_2, \ldots, x_n)$, usually coordinates in the search space
- evaluation is the calculation of each individual's fitness value
- selection eliminates part of the population, keeping preferably the best individuals
- evolution applies genetic operators (crossover, mutations…), leading to new individuals in the population.

Fly algorithm – obstacle avoidance using stereovision



Fly algorithm – obstacle avoidance using stereovision



Fly algorithm – fitness

$$F = \frac{|\nabla(M_L)| . |\nabla(M_R)|}{\sum_{colours} \sum_{(i,j)\in N} [L(x_L + i, y_L + j) - R(x_R + i, y_R + j)]^2}$$

where:

- (x_L, y_L) and (x_R, y_R) are the coordinates of the left and right projections of the current individual
- $L(x_L+i\ ,\ y_L+j)$ is the grey value at the left image at pixel $(x_L+i\ ,\ y_L+j)$, similarly with R for the right image
- N is a neighbourhood around the projection of each fly, introduced to obtain a more discriminating comparison of the flies
- $|\nabla(M_L)|$ and $|\nabla(M_R)|$ are Sobel gradient norms on left and right projections of the fly. That is intended to penalise flies which project onto uniform regions, i.e. less significant flies.

Sobel operator for edge detection

Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical. If we define **A** as the source image, and $\mathbf{G}_x$ and $\mathbf{G}_y$ are two images which at each point contain the horizontal and vertical derivative approximations, the computations are as follows:

$$\mathbf{G}_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ +1 & +2 & +1 \end{bmatrix} * \mathbf{A} \quad \text{and} \quad \mathbf{G}_x = \begin{bmatrix} -1 & 0 & +1 \\ -2 & 0 & +2 \\ -1 & 0 & +1 \end{bmatrix} * \mathbf{A}$$

where * here denotes the 2-dimensional convolution operation.

The *x*-coordinate is here defined as increasing in the "right"-direction, and the *y*-coordinate is defined as increasing in the "down"-direction. At each point in the image, the resulting gradient approximations can be combined to give the gradient magnitude, using:

$$\mathbf{G} = \sqrt{\mathbf{G}_x^{\,2} + \mathbf{G}_y^{\,2}}$$

Using this information, we can also calculate the gradient's direction:

$$\mathbf{\Theta} = \arctan\left(\frac{\mathbf{G}_y}{\mathbf{G}_x}\right)$$

where, for example, $\mathbf{\Theta}$ is 0 for a vertical edge which is darker on the left side.

Fly algorithm – operators

Selection is elitist and deterministic. It ranks flies according to their fitness values and retains the best individuals (around 40%).

A sharing operator [7],[8] reduces the fitness of flies packed together and forces them to explore other areas of the search space.

Barycentric crossover:

$$\vec{OF} = \lambda \vec{OF_1} + (1-\lambda)\vec{OF_2}$$

with λ chosen at random in the interval [0,1].

Gaussian mutation, immigration

Fly algorithm in use

Fly algorithm - control

- the fly is near the vehicle
- the fly is in front of the vehicle (i.e. close to the z axis)
- the fly has a good fitness.

- flies more than 2 metres above the road surface
- flies with a height under 10 centimetres (detecting the ground)
- flies more than 16 metres ahead of the vehicle.

Fly algorithm - control

$$warning(fly) = \frac{F}{x^2 \times z}$$

For $|x| < 0.5$ m we consider $x = 0.5$ m, and for $z < 1$ m we consider $z = 1$ m. This is to avoid giving excessive warning values to flies with a not necessarily good fitness but with a very small x or z coordinate. Moreover, obstacles within a range of half a metre to the left or to the right from the centre of the vehicle ($|x| < 0.5$ m) are equally dangerous, and are consequently processed the same way.

CMAES

See the tutorial in the materials...

MOEA

See the paper in the materials...