Image re-morphing, noise removal, and feature extraction with swarm algorithm

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Beyond modeling social and dynamic behaviors of groups, swarm algorithms were recently used in various domains like epidemiology, optimization, planning, robotics, classification, and image processing – including medical applications, e.g. [1], [2]. Recently, ant colony swarm algorithms have been successfully used in medical image processing.

After a brief overview of existing techniques already applied to image processing by PSO (particle swarm optimization) and other swarm-based techniques, we expose the principles and equations governing the dynamics of the swarms used by us in image processing. The image processing method proposed here differs in radical manner from those previously suggested (such as algorithms using ant pheromone traces).

Our method draws a dynamic picture of the collectively, locally perceived "landscape" of the image. The image is interpreted by the swarm as a three-dimensional environment, with tones of grey representing different "altitudes". Surface features behave similarly to swarm agents: they repel the swarm at close distance and attract it at larger distances. The radius at which the force changes from repelling to attraction is an important parameter of the shape characterization and related image processing. A swarm can be trained by changing its parameters, like number of agents, distance function type, threshold distance, force constant multiplier, force bias, for the swarm to best process and discriminate shapes. Once the swarm has adapted to a set of images, it can be used to derive the parameters of the shape, to remove noise, or perform image morphing operations.

By their inertial terms in the motion equations, swarms act as nonlinear, integrating filtering systems. Moreover, by the distance functions used in the swarming control equations, the filtering effect is non-linear, moreover it is adjusted. We analyze the filtering effects of the implementations of the concept of "swarm filter" introduced in this paper.

Image processing results will be presented and contrasted with results obtained using established methods. The method is applied to medical image processing and we exemplify the results on radiological images.

References

[1] Huang, P. Cao, H., Luo, S., *An artificial ant colonies approach to medical image segmentation*, Computer Methods and Programs in Biomedicine 92, pp. 267-273, Elsevier, 2008

[2] Ma, L., Wang, K., Zhang, D., *A universal texture segmentation and representation scheme based on ant colony optimization for iris image processing*, Computers and Mathematics with Applications 57, pp. 1862 – 1868, Elsevier, 2009