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Visual tracking using improved flower pollination algorithm

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ABSTRACT

Flower pollination algorithm (FPA) is a new meta-heuristic optimization algorithm that mimics the real life processes of the flower pollination. FPA has been proven to be an effective tool in solving plenty of global optimization problems. In this study, visual tracking is considered to be a process of optimal reproduction of flowering plants. Meanwhile, an Improved Flower Pollination Algorithm (IFPA) is presented with the switch probability p changing dynamically with generation number. An IFPA-based tracking architecture is presented and the parameters' sensitivity and adjustment of IFPA in tracking system are studied experimentally. To verify the tracking ability of the proposed tracker, comparative studies of tracking accuracy and speed of the proposed tracker with particle filter, mean shift and PSO are presented. Comparative results show that the IFPA-based tracker outperforms the other three trackers.

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1. Introduction

With the rapid developments and applications of computer vision, more and more attentions have been paid on visual tracking [1–3]. However, visual tracking is still a challenging task because it often suffers from difficulties in handling complex factors in real world scenarios, e.g. partial occlusion, shape deformation, illumination variation, camera motion, etc.

Visual tracking can be regarded as a process of searching for the most similar candidate region of the target by an efficient target representation [4]. A robust appearance model and an efficient search strategy are of crucial importance for a tracker. Recently, great efforts have been spent on appearance model building [5]. Conversely, the attentions paid on the search strategies are not so much.

In general, there are two representative search strategies, namely, deterministic methods and probabilistic methods [4]. Deterministic methods locate targets in each frame by searching for a region iteratively which maximizes the similarity measure between this region and the target window. A representative deterministic method is meanshift [6]. Probabilistic methods regard tracking process as a state solving problem under the Bayesian framework, modeling uncertainty and propagating the conditional densities through the tracking process. Particle filter is a typical method of these methods [7].

Recently, many researchers start to solve visual tracking problems using more "intelligent" searching strategies. For example, Zhang et al. proposed a tracking method based on particle swarm optimization (PSO) [8]. In their work, the parameters that control the movement of the particles in the swarm were updated dynamically depending on the fitness values of the particles. Experimental results showed that the proposed tracker was more robust and effective than particle filter and unscented particle filter. Fourie et al. designed a visual tracking system based on improved harmony search algorithm (IHS) [9]. In their work, the target location was obtained using IHS algorithm. Experimental results showed that IHS was able to

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track poorly modeled targets in real time. Recently, Gao et al. proposed a bat algorithm (BA) based tracker [10]. In their work, visual tracking is considered to be a process of searching for target by various bats in sequential images and experiments show that the proposed tracker performed well in various challenging tracking examples.

Flower pollination is an intriguing process in the natural world. Inspired by the pollination process of flowering plants, Yang proposed the flower pollination algorithm (FPA) [11]. Preliminary studies indicated that FPA had superior performance over genetic algorithms (GA) and PSO for various standard test functions [11]. Since the emergence of this algorithm, it has been applied to a wide range of optimization applications including economic dispatch, cluster analysis, and truss structures [12–14], etc. In FPA, the switch probability is used to switch between global pollination to local pollination. The traditional FPA uses fixed value for switch probability and cannot be changed during new generations. The main drawback of this method appears in the number of iterations the algorithm needs to find an optimal solution.

In this study, an Improved Flower Pollination Algorithm (IFPA) is proposed with the switch probability p changing dynamically with generation number. Then a novel visual tracking method based on IFPA is proposed. To demonstrate the tracking ability of the proposed tracker, comparative studies of tracking accuracy and speed of the proposed tracker with three representative trackers, namely, particle filter, meanshift and PSO are presented. Comparative results show that the IFPA-based tracker outperforms the other three trackers.

2. Flower pollination algorithm for visual tracking

2.1. Flower pollination algorithm

Recently, Yang proposed the flower pollination algorithm (FPA) which was inspired by the pollination process of flowers. There are two key steps in FPA, namely, global pollination and local pollination. FPA is idealized as four rules [11].

(1) The global pollination processes are biotic and cross pollination through which the pollen transports pollinators perform the levy flight.
(2) Local pollination is viewed as abiotic and self pollination.
(3) Reproduction probability is considered as flower constancy which is proportional to the resemblance of the two flowers in concerned.
(4) A switching probability $p \in [0,1]$ controls the local and global pollination.

In the global pollination step, flower pollens are carried by pollinators e.g. insects. Pollens can travel over a long distance because insects can often fly and move in a long range. This ensures the pollination and reproduction of the most fittest g_*. The first rule plus flower constancy is represented mathematically as:

$$\mathbf{x}_i^{t+1} = \mathbf{x}_i^t + L(\mathbf{x}_i^t - g_*) \tag{1}$$

where x_i^t is the pollen i at iteration t, and g_* is the current best solution found among all solutions at the current generation. The parameter L is the strength of the pollination, which essentially is a step size.

Since insects may move over a long distance with various distance steps, a Levy flight is adopted to mimic this characteristic efficiently [15,16]. A Levy distribution is represented as:

$$L \sim \frac{\lambda \Gamma(\pi\lambda/2)}{\pi} \frac{1}{s^{1+\lambda}}, (s \gg s_0 > 0) \tag{2}$$

Here, $\Gamma(\lambda)$ is the standard gamma function with $\lambda = 1.5$, and this distribution is valid for large steps $s > 0$.

The local pollination and flower constancy can be represented as:

$$\mathbf{x}_i^{t+1} = \mathbf{x}_i^t + \varepsilon(\mathbf{x}_j^t - \mathbf{x}_k^t) \tag{3}$$

Where $\mathbf{x}_j^t$ and $\mathbf{x}_k^t$ are pollens from the different flowers of the same plant species. This essentially mimics the flower constancy in a limited neighborhood.

Most flower pollination activities can occur at both local and global scale. In practice, adjacent flower patches or flowers in the not-so-far-away neighborhood are more likely to be pollinated by local flower pollens that those far away. For this, a switch probability p is used to switch between global pollination to intensive local pollination.

2.2. Improved flower pollination algorithm

The switch probability p is used to switch between global pollination to local pollination. It is an important parameter in fine-tuning of optimized solution vectors,and it can be potentially useful in adjusting convergence rate of algorithm to optimal solution. The traditional uses fixed value for switch probability and cannot be changed during new generations. The main drawback of this method appears in the number of iterations the algorithm needs to find an optimal solution.

In early generations, a large switch probability will most likely drive the flowers to the global pollination processes which increases the diversity of solution vectors. A small switch probability in final generations usually drive the flowers to the local pollination processes which increases the fine-tuning of solution vectors to optimal solution vector.

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