Video-based Tancho Koi Fish Tracking System Using CSK, DFT, and LOT

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Abstract. In this paper, a comparison of Circulant Structure of Tracking-by-detection with Kernels (CSK), Distribution Fields for Tracking (DFT) and Locally Orderless Tracking (LOT) methods is proposed for the process of video-based object tracking. The object in question is the tancho koi fish and its variants, in the form of video recordings. All three methods are applied to trace the red roundabout in the head of the koi fish. The purpose of this study is to provide the best tracking process recommendations for this case. From the experimental results, it is found that the average sample accuracy of the DFT tracking method is more recommended than the other two methods, even though it has an average frame rate that is no better than the CSK method.

1. Introduction

Koi Fish (*Cyprinus carpio*) is one of the ornamental fish that not only has a high selling price but is also very popular. This koi fish has a very varied color, has a very beautiful and tame ornament. Koi are usually maintained in ponds inside the house or outdoors because koi fish look so beautiful when viewed from above, precisely the beauty of the koi can be enjoyed from the color of its back. The type of koi fish is distinguished depending on the color, pattern, and size. Some of the color elements are white, black, red, yellow, blue, and cream.

Research on koi fish is always interesting to do. Some studies related to the maintenance of koi fish can be mentioned as follows: [1] - [6]. Research on koi fish is usually related to maintaining the water quality of the koi environment, especially the right needs of Dissolved Oxygen (DO), Degree of Acidity (pH), Temperature, brightness, and Ammonia (NH3). Other studies include feeding arrangements to maintain koi color quality and prevention of disease.

Meanwhile, research on video object tracking is currently no less interesting. This research is based on the need for the importance of observing objects and activities or movements both in real time and video-based as material for further analysis. Object tracking for observing koi fish movements is important to know the activity of koi fish. At least from monitoring the movement of koi fish it can be seen that the koi fish is moving (alive) or not moving (dead).

Several studies on object tracking that can be used as thought material for koi fish movement monitoring needs include Circulant Structure of Tracking-by-detection with Kernels (CSK) [7], Distribution Fields for Tracking (DFT) [8], and Locally Orderless Tracking (LOT) [9]. Other
researches about object tracking methods include: Improved Mean Shift [10] - [13], fuzzy systems [14] - [19], and deep learning [20] - [26]. This paper proposes tracking the movement of koi fish using the CSK, DFT and LOT methods where the types of koi fish tracked are the tancho koi fish and some tancho koi variants.

2. Circulant Structure of Tracking-by-detection with Kernels (CSK)
The CSK method is taken from the paper [7]. Withdrawing from the truth that nearly all strategies accessible for object tracking have one thing in common: meager examining technique. In each outline, a few samples are collected within the target environment, whereas a rule each sample characterizes subwindows of the same estimate as targets that cause a part of excess since most samples have a part of the cover. This essential structure is as a rule disregarded. Instead, most strategies as it were collect a little number of samples.

The fact that preparing information encompasses a part of repetition implies we might not abuse its structure efficiently. The CSK strategy proposes a hypothetical framework to overcome this. Within the paper [7] it has appeared that the method of taking subwindows from an image actuates a circulation structure. At that point, an interface to Fourier examination is made which permits the utilize of Quick Fourier Change (FFT) to rapidly enter data from all subwindows, without rehashing it.

3. Distribution Fields for Tracking (DFT)
The DFT method is taken from the paper [8]. Visual tracking of common objects frequently depends on the presumption that the slope plummet of the arrangement work will reach the ideal global. The common procedure for refining the objective work is by obscuring the image. In any case, obscuring the image harms image data, which can cause the target to vanish. To overcome this issue a strategy is utilized to construct image descriptors employing a dissemination field (DF), a representation that permits smoothing objective capacities without harming data almost pixel values.

Experimental prove is displayed on the predominance of the width of the malleable bowl around ideal global DF over other descriptors. DF too permits the representation of vulnerability approximately the object being tracked. This makes a difference in disregarding exceptions amid following (such as occlusion or little misalignments) without explicit modeling. A simple way is given to gather object perceptions through time and keep up an overhauled demonstrate. Displayed a simple tracking algorithm that employments DF and gets the most recent comes about on standard benchmarks.

4. Locally Orderless Tracking (LOT)
The LOT method is taken from the paper [9]. LOT is a visual tracking algorithm that consequently gauges the number of neighborhood unsettling influences in an object. This permits trackers to specialize in unbending objects and can be deformed online and without earlier suspicions. It is offered a probabilistic model of object variety over time. This demonstration is actualized utilizing Earth Mover's Distance (EMD) with two parameters that control the fetched of moving pixels and alter their color. It is altered these costs online during following to the account for the sum of impedances within the object.

5. Proposed Methodology
This study proposes a comparison of the three methods, namely CSK, DFT and LOT to see its performance in the application of object tracking video. The object to be tracked is in the form of a red circle on the head of the tancho koi fish with various variants in the form of video recordings.

Koi with a red roundabout on the head is known as koi tancho. Many tancho koi variants include Tancho-Asagi, Tancho-Goshiki, Tancho-Sanke, and Tancho-Showa Koi Fish. For the purposes of this study, each sample was taken by 4 frames. From the four frame samples, the accuracy of the success of tracking each method is calculated. Besides that, it is also calculated using frame rate (expressed in frames per second or FPS) the speed of the tracking process of the entire video frame. The frame rate is the frequency (rate) at which consecutive images called frames appear on a display. The proposed methodology flow chart as shown in Figure 1.
6. Results and Discussion
The three tracking algorithms (CSK, DFT and LOT) were tested on 5 video recordings of tancho koi fish and their variants. This algorithm is applied to trace the red roundabout in the head of the koi fish. The results of the experiment using the CSK, DFT and LOT methods, each taken 4 frame samples.

From the sample test results of Video 1, is obtained the tracking accuracy results using the CSK and DFT methods are very good. All frames show perfectly tracked objects (100%). But the object is only tracked in part (2 of 4 or 50%) when the LOT method is used. In addition, the speed of the tracking process using the CSK method is very high, 225.5 fps, compared to the other two methods, namely DFT 1.9 fps and LOT 0.3 fps.

From the sample test results of Video 2, is obtained the tracking accuracy results using the LOT method are better than the other two methods (3 of 4 or 75%). In addition, the speed of the tracking process using the CSK method is higher than the other two methods, but the sample accuracy looks the worst. CSK frame rates are 36.6 fps, DFT 1.7 fps, and LOT 0.2 fps.

From the sample test results of Video 3, is obtained the tracking accuracy results using all three methods are equally good (100%). All frames show perfectly tracked objects. The speed of the tracking process using the CSK method remains higher than the other two methods. CSK frame rates are 64.4 fps, DFT 1.9 fps, and LOT 0.3 fps.
Finally, from the sample test results of Video 5, is obtained the tracking accuracy results using the three methods are equally bad. Only the tracking of the DFT method shows that it can still track a portion (1 in 4 or 25%). While the process speed using the CSK method remains higher than the other two methods. CSK frame rate is 139.5 fps, DFT 0.8 fps and LOT 0.2 fps. An example of object tracking results in Video 1 is shown in Figure 2. The complete results of all tests in Frame per Second (FPS) and Sample Accuracy (%) are summarized in Table 1.

![Image](image_url)

**Figure 2.** The example of object tracking test results using Video 1. Tancho Koi Fish Tracking using (from the top) CSK, DFT and LOT. Tracking results of frames 45, 90, 135, 178 are displayed.

| Video | Number of frames | CSK   | DFT   | LOT   |
|-------|------------------|-------|-------|-------|
|       |                  | FPS   | %     | FPS   | %     | FPS   | %     |
| 1     | 178              | 225.5 | 100   | 1.9   | 100   | 0.3   | 50    |
| 2     | 138              | 36.6  | 0     | 1.7   | 50    | 0.2   | 75    |
| 3     | 146              | 217.8 | 50    | 1.9   | 100   | 0.6   | 100   |
| 4     | 52               | 64.4  | 100   | 1.9   | 100   | 0.3   | 100   |
| 5     | 595              | 139.5 | 0     | 0.8   | 25    | 0.2   | 0     |
| Average|                  | 136.8 | 50    | 1.6   | 75    | 0.3   | 65    |

*Table 1. Object Tracking Results.*

From the test results in Table 1, object tracking using the CSK, DFT and LOT methods on 5 video recordings of the tancho koi fish and its variants, through tracking the red roundabout on its head, can be analyzed as follows. The average processing speed using the CSK method is higher than the other two methods. The average frame rate of CSK 136.8 fps, DFT 1.6 fps, and LOT 0.3 fps. Even though the frame rate tracking is the best, CSK has the worst average sample accuracy (50%), compared to the DFT (75%) and LOT (65%) methods. With the average frame rate better than the LOT method, even though it is under CSK, but with the best average sample accuracy, the DFT method is recommended in solving this case.
7. Conclusion
This paper proposes a comparison of CSK, DFT and LOT methods for video-based object tracking. The object in question is the tancho koi fish and its variants. These three methods are applied to trace the red roundabout in the head of the koi fish. From the experimental results, it is found that the average sample accuracy of the DFT tracking method is more recommended than the other two methods, even though it has an average frame rate that is no better than the CSK method.

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