Object Tracking using Proposed Framework of KalmanGuided Harmony Search Filter

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Abstract.

In this paper an improvementon the harmony filter is done by adding the Kalman filter after the improvisation process, toguide the filter to reach the convergence state at the lowest possible number of iterations, which means more ability for tracking the moving objects in real time performance, which is a crucial factor in the multi object tracking applications.

KeyWords: object tracking, Harmony filter, Kalman filter

تتبع جسم باستخدام اطار مقترحلمرشح كالمان كموجه لمرشح الهارموني

الخلاصة

في هذا البحث تم تطوير فلتر البحث الهارموني وذلك باضافة فلتر كالمان اليه بعد عملية الارتجال لغرض توجيه فلتر الهارموني للوصول الى حالة التقارب باقل عدد ممكن من التكرارات،وهومايعني المزيدمن القدرةعلى تتبع الأجسام المتحركة في الأداءفي الوقت الحقيقي،والذي يعتبر عامل حاسم في تطبيقات تتبع الكائنات المتعددة.

الكلمات المرشدة: تتبع الفيديو-فلتر الهارموني- فلتر كالمان

1.Introduction:

The tracking of objects in video sequences for surveillance by camera is demand application nowadays. Automatic tracking for targets may be the basic fornumerous interesting applications ranging from remote surveillance to video
production, and from interactive immersive games to robotics. An efficient and accurate tracking ability at the heart of such a system is fundamental to build higher level intelligence in vision-based.

Visual object tracking has been addressed by many algorithms,all these algorithms face the same challenges. The main challenge of the tracking task is localizeing the exact position of the moving target object in the camera's field of view. The difficulty of tracking problem is due to principal three challenges:

- Variations in the target pose or target deformation
- Variations in the illumination.
- Partial or full occlusions of the target object.

No way for the algorithm to bypass one of these challenges, otherwise inaccurate results is gotten. The tracking should also be done with computational efficiency, to make possible for real time applications.

2. Related work

Many researchers have tried various approaches for object tracking. Some of the research work done in the field of object tracking includes:

i- The paper of Ahmed Ali and Kenji Terada, 2010 [10], titeled “**A General Framework for Multi-Human Tracking using Kalman Filter and Fast Mean Shift Algorithms**”, In this paper, a framework is presented for multi-Human tracking. The key contribution of the work is to use fast calculation for mean shift algorithm to perform tracking for the cases when Kalman filter fails due to measurement error. The proposed approach has the robust ability to track moving objects, both separately and in groups, in consecutive frames under some kinds of difficulties such as rapid appearance changes caused by image noise and occlusion.

ii- JacoFourie, in his thesis, 2011 [1], “**The Application of Harmony Search in Computer Vision** “a novel adaptation is made to the harmony search algorithm to improve performance of the visual tracking system to track single object.

iii- The paper of Amir Salarpour, ArezooSalarpour, Mahmoud Fathi, and MirHossein Dezfoulian1, 2011 [12],that titled “**Vehicle tracking using Kalman filter and color features**” describe a method, for tracking multiple objects, where the objects are vehicles. For tracking of vehicle they use the Kalman filter and color feature and distance of it from one frame to the next. So this method can distinguish and tracking all vehicles individually.

iv- The paper of N. Prabhakar, and V. Vaithiyanathan, 2012 [11], titled "**Object Tracking Using Frame Differencing and Template Matching",** proposed object tracking system that uses concepts of frame differencing and template matching. The templates used for matching purpose are generated dynamically which ensures that the change in orientation and position of object does not hinder the tracking system

3. Tracking problem solution by an optimization method

Visual tracking can be modeled as a more general optimization problem. Instead of looking for successive localization of the moving object in sequences of a video,the Region Of Interest (ROI) are considered to captures the object and distinguished it from the background. The target must be modeled accurately to make it distinguishable from the background and to make possible to use a similarity measure as an objective function that allows to measure how close the region of interest is in completelycapturing the target without any of the background.

Based on this approach one can construct a complete visual tracking system with the following three components [1]:

1- The target model:

The target model has to accurately capture the features that are unique to the target so it can be robustly distinguished from other objects in the image and from the background, like histogram.

2- The objective function:

The objective function is a metric that measures how close the localized region fits the target model, like Bhattacharyya coefficient.

3- The optimization algorithm:

The optimization algorithm is responsible for finding the optimum solution in the objective function, like harmony search algorithm.

4.Harmony Search algorithm HS:

HSA is one of a population-based meta-heuristic optimization methods. This algorithm adopts the style of the musicians in improvisation of their notes, to find the optimal solution of any problem that can be described as optimization problem. To please their audience,themembers of the jazz band have to improvise their harmony by combining several notesbythree ways . They must also divide the musical performance between these three methods in different proportions in order to get the best results for satisfying the audience. The first method is to play random notes.This method will get the least percentage of the total performance because it is risky to play notes for the first time that it is impossible to guess the reaction of the audience towards these notes. The second method is to play renowned notes(famous music that are composed by another musicians) that are stored in the memory of each player. This will get the bigger percentage of the performance because the reaction is known and guaranteed . The third one is to modify or adjust the memorized renowned notes with little bit of adjustment for seeking better harmony. This also will be done in a specified percentage .The reaction of the audience is the feedback for the band to choose the best harmony that will get the higher acceptance. Definitely, it is not possible for the band to improvise the best harmony from the first trial. It must be done by the method of the trial and error and for many times (iterations).If all the notes played by the band are seen as harmonious, then it will be stored in the memory of all the members of the band for the future use [1].

HSA is divided into five steps as follows [2]:

Step #1: Initiate the parameters of HSA.

Step #2: Initialize the Harmony Memory(HM).

Step #3: Improvise new solution.

Step #4: Update the HM.

Step #5: Repeat steps #3 and #4 until reaching the stopping criteria.

Step#3 and step#4 willrepeaedt while the termination criterion (number of improvisations) is not reached.

In 2011, JacoFourie proposed the Harmony Search filter HS [1]. The HSfilteruses a color histogram model to model the target. Localization of the target is achieved by comparing histogram models of candidate localizations with that of the target.The model that represents the correct localization will be most similar to the target model. This similarity is measured using the Bhattacharyya coefficient according to the equation:

$$d_{\text{Bhattacharyya}}(H_1, H_2) = \sqrt{1 - \sum_i \frac{\sqrt{H_1(i) \cdot H_2(i)}}{\sqrt{\sum_i H_1(i) \cdot \sum_i H_2(i)}}} \qquad (1)$$

where$H_1$and $H_2$are the normalized histograms beingcompared, and i is the index of the bin of the histogram.

The Bhattacharyya coefficient measures the distance between the targethistogram and improvised histogram.Low scores indicate good matches and high scores indicate bad matches. A perfect match is 0 and a total mismatch is a 1[5].

The harmony filter finds the most optimal localization by using improvisation process to find the best solution by minimize the Bhattacharyya coefficient between the target histogram model and a histogram model from a candidate localization.

The architecture of the harmony filter consists of two components. The main tracker part manage the operations of reading, displaying the frames with the results of the tracking (rectangle label) and extract the template histogram.The second part of the system is the Harmony-Search-basedoptimizer. It is responsible of finding the best solution and locating the target in the image frame [1].

5. The Kalman filter algorithm

The Kalman filter estimates a process by using a form of feedback control: the filter estimates the process state at some time and then obtains feedback in the form of (noisy) measurements. As such, the equations for the Kalman filter fall into two groups: time update or predictor equations and measurement update or corrector equations.Indeed the final estimation algorithm resembles that of a predictor-corrector algorithm for solving numerical problems is shown in Figure-1.When the derivation of Kalman filter equations from is gotten [3].

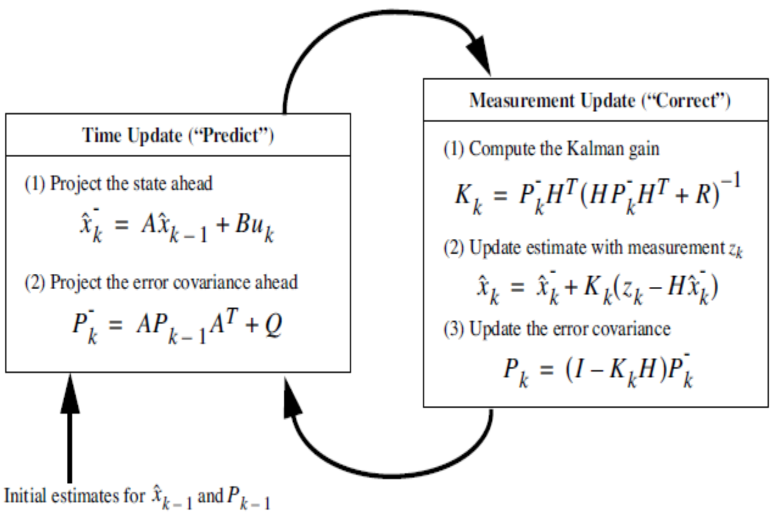

Figure 1 Complete picture of operation of Kalman filter [4]6. the proposed KalmanGuided Harmony Search filter:

The proposed approach is the Kalman guided Harmony search filter KGHS algorithm. The architecture of the Kalman guided Harmony search KGHS consists of two phase work in synergistically manner, these phases are:

phase-1: Harmony search

phase-2KalmanFilter.

The Harmony search algorithm improvise around the tracking object in all spatial directions, this process need long computational time. The Kalman filter KF used to smooth noisy data with small computation time but it has one restriction due to its linear estimation with Gaussian error statistics. So if Kalman filter is combined with the Harmony search HS to achieve balance between the speed of Kalman and the extended nonlinear search in the Harmony search.
In all optimization methods, there are two key factors that play principal role in the speed and accuracy of the search process to find the optimal solution. These are

1-global diversification

2- thelocal intensification,which called also the exploration and exploitation.

The exploration is the randomization of the search, which enables an algorithm to have the ability to jump out of any local optimum so as to explore the search globally.

Exploitation is the use of local knowledge of the search and solutions found so far so that new search moves can concentrate on the local regions or neighborhood where the optimality may be close; however, this local optimum may not be the global optimality. The key is to balance between these two manner of search. There is no constant rule for achieving this balance, the exploitation tends to increase the speed of convergence, while exploration tends to decrease the convergence rate of the algorithm. On the other hand, too much exploration increases the probability of finding the global optimality but with a reduced efficiency, while strong exploitation tends to make the algorithm being trapped in a local optimum. In HS filter, high value of Harmony Memory Consideration ratio HMCR means high exploitation, while high value for Pitch Adjustment Rate PAR means high exploration.

Practically, it is better to reduce the value of HMCR to increase the randomness of the search operation to prevent local optimatrap. In the same time Kalman filter will guide the search operation and as a tool for more exploitation to compensate the decreasing of HMCR. There are no benefit from PAR and it is better to put PAR equals zero, especially after increasing the randomness by decreasing HMCR. In fact, increasing PAR value increases the number of iterations without getting any benefits by destroying the positive effect of Kalman filter, hence decreasing the efficiency of the search.

The main idea of the KGHS filter performance improvingis to insert Kalman filter after the improvisation process of HS filter, to guide the convergence process to the optimal solution with the least number of iterations. The tracking process is done by the improvisation process which predict target location according to the dynamic system equations and by adding a random value of preset variance for acceleration, and then extract the histogram of the region of interest which have a centroid of the same co-ordinates of the predicted location and an area which had been specified randomly from uniform distributed interval of the scale. The extracted histogram is compared with template histogram of the target that had been extracted from the first frame, to get the cost fitness value by means of similarity measure (Bhattacharyya coefficient for histogram matching) . If the cost fitness is better than the worst cost fitness stored in HM memory, then the improvised target location is transferred to Kalman filter before exchanged it with the target location of the worst cost fitness, otherwise, it is ignored. Kalman filter will correct the target location to bring it more closer to the ground truth(exact target location). In this way, the improvisation process is guided towards the optimal solution more and more as the iterations proceed, in the same way of the filtering of the digital voltmeter measurements to get the estimated voltage value after filtering all the introduced noises. The steps of the KGHS is listed in algorithm(1).

Algorithm (1): Kalman guided Harmony Search (KGHS) Filter

Input : video frames

Output: display the video with bounding box around the tracking object

Step1:start

Step2: HMCR= 0.1

Step3: for t = 1 to frame-number //repeat for each frame //

Step4: // drag the mouse over the object to determine the region of interest ROI//

x(t) = x-axis of the centroid of ROI

y(t) = y-axis of the centroid of ROI

Step5: template-hist= histogram(ROI)

Step6: while not (convergence test) do

r_1 = a random value

if r_1 <= HMCR then choose a new location from HM else

a-x = a random value as an acceleration noise for x axis

a-y = a random value as an acceleration noise for y axis

x(t+1) = x(t) + a-x /*improvise a new candidate */

y(t+1) = y(t) + a-y

improvised-hist = histogram (improvised object)

similarity-measurement = Bhattacharyya between template-hist and improvised-hist

if the similarity-measurement is better than the worst similarity-measurement stored in HM then Call Kalman Filter with the improvised object location [x(t+1), y(t+1)]

store the returned object location with its similarity-measurement in the HM

step7: end /* while */

Step8: new-target = the object with minimumsimilarity-measurement from Harmony Memory HM

Step9: label the target by a bounding box in the frame

Step10: end

7. Experimental results

Power of any proposed algorithm arises when it is tested. This section presents the experimental results of implementing the proposed object tracking algorithms to track object in a video film.Two sample videos are chosen. In the first samplevideo (43 frames), a moving camera is used to film a moving person indoors, with changes in illumination (Figure 2). In the second sample video (27 frames), a stationary camera is used to film a moving car outdoors(Figure 3) .

Figure 2: video sample-1 Figure 3; video sample-2

The aim from these experiments is to get answer to the question :How to achieve best balance between the diversification and intensification of the search?

This can be achieved by changing the values of HMCR and PAR to get the best performance of the proposed KGHS filter, where best accuracy means least distance error, and best speed means lowest number of iterations. The obtained results are illustrated in tables (1) and (2).

Table-1 Experimental resultsof applying KGHS on sample video1

	HMCR (%)	PAR (%)	Distance Average (pixels)	Iteration Average (iterations)
HS filter	0.95	0.14-0.56	2.6	34.2
KGHS filter	0.95	0.14-0.56	2.3	29.9
KGHS filter	0.95	0.0	2.8	26.6
KGHS filter	0.5	0.0	2.8	7.3
KGHS filter	0.4	0.0	2.3	6.3
KGHS filter	0.3	0.0	1.9	6.1
KGHS filter	0.2	0.0	2.5	5.5
KGHS filter	0.1	0.0	2.3	5.2
KGHS filter	0.0	0.0	2.3	19.8

Table-2: Experimental resultsof applying KGHS on sample video2

	HMCR (%)	PAR (%)	Distance Average (pixels)	Iteration Average (iterations)
HS filter	0.95	0.14-0.56	3.1	25.2
KGHS filter	0.95	0.14-0.56	2.6	27.9
KGHS filter	0.95	0.0	3.1	21.9
KGHS filter	0.5	0.0	2.8	11.7
KGHS filter	0.4	0.0	3.0	10.2
KGHS filter	0.3	0.0	2.8	12.6
KGHS filter	0.2	0.0	3.3	10.3
KGHS filter	0.1	0.0	2.1	9.6
KGHS filter	0.0	0.0	2.0	19.8

The speed is improved drastically by decreasing the value of HMCR from (0.95) down to (0.1) to reach the iteration average of (5.2) iterations with the decreasing of (29)iterations compared with the HS filter as shown in (Table 1).

As previouslymentioned, the adjustment of the PAR cancel the effect of the Kalman filter.The accuracy of the KGHS filter when PAR parameter is (0.14-0.56%) of the improvisations is (2.3) pixels and with (29.9) iterations for the speed.

For this reason the adjustment of the improvised solutionsis cancelled, and in the same time the random improvisation percentage of the improvisation is increased to compensate the reduction of the diversification that caused by cancelling the adjustment. The results shows a steadily improvement with the increasing value of the random improvisation by decreasing the value of HMCR down to (0.1%)(the shaded row). The diversification in the search process of is 90% and the intensification is 10% with the addition of the intensification that achieved from the Kalmanfilter . But the performance of the KGHS filter degrades when the memory consideration of the solutions is completely cancelled by making HMCR equals to (0.0%).

For the car tracking video, the measurements gives the same returns approximately, with different result’s values as shown in (Table 2).

8.Conclusion

The proposed algorithm in this paper is improved the set up system for tracking an objects and finding trajectory in a video sequence by using the Kalman filter to tuning and improving the performance of the harmony search filter and guiding the filter to reach the convergence state at the lowest possible number of iterations. The improved algorithm is tested and givesgood results from speed and accuracy point view compared with Harmony search algorithm.

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