Unsupervised Automatic tracking of Thermal changes in Human Body

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An automated system for detecting and tracking of the thermal fluctuation in human body is addressed. It applies HSV based k-means clustering which initialized and controlled the points which lie on the ROI boundary. Afterward a particle filter tracked the targeted ROI in the thermal video stream. There were six subjects have voluntarily participated on these experiments. For simulating the hot spots occur during the some medical tests a controllable heater utilized close to the subjects body. The results indicated promising accuracy of the proposed approach for tracking the hot spots. However, there were some approximations (e.g. the transmittance of the atmosphere and emissivity of the fabric) which can be neglected because of independency of the proposed approach for these parameters. The approach can track the heating spots efficiently considering the movement in the subjects which provided a confidence of considerable robustness against motion-artifact usually occurs in the medical tests.

I. Introduction

The medical applications of thermography have expanded more than a decade[1] in the very broad categories and involve various fields of medicine such as breast cancer [2,3], dermatology [4,5], avian flu [6,7], dentistry [8,9], psychology[10], prevention. Measuring the body temperature through non-invasive method is a challenging task which involves many researchers in the field of thermography to itself. Utilization of the thermal instruments provides a powerful tool for avoiding the invasive operations which give inconvenient circumstances for the human subject. In some cases, it is not possible to use some other methods like thermometers, particularly under the radiological exposure that any external tools might give some artifacts or possible issues. Here, a thermal image processing techniques for finding and tracking the thermal spots within the increasing at the temperature. It involves the authors to voluntarily participant as human subject experiment for thermal spot tracking.

II. Proposed method for automatic tracking the hot spots

Having the knowledge of overheating gives the possibility to imply thermographic devises and consequently create a system for automatic detection and tracking the heating spots seems needed using thermal image/video analysis. Here, the approach presents a system which automatically detects and tracks the hot spots within the thermal video sequence. There is an initialization and control possible points which have heated and lie on the boundary of a region of interest (ROI) in every frame of thermal video stream. The ROI initialization is needed for detecting the overheating spots and initiates an automatic particle filter tracking process.

A. Unsuppervised Clustering in HSV

For clustering of the thermal image obtained from the experiments. The main and first question which might be asked is why to use of Hue Saturation Value (HSV) for unsupervised clustering of thermal image. The simple answer can be due to separation of *luma*, whose contains intensity information of the image, from *chroma* which has color information. It is more unlikely for the RGB color system which is normally using for the purposes of clustering. It is due to the reason that it gives the robustness to removing shadows or lighting variations. In the RGB color system, the implementation details regarding the color display are concerned however in the HSV there is the actual color components are in target. It means the RGB is more a computer treated way of the color to be shown and HSV is more look-like the capture of the components in the way of humans perceives the color. Response (or resonation) of the human eye is only limited to three main light frequencies not to red, green and blue surprisingly which is not linear and provides pure color distinguish response of the retina combining three color component responses.

Besides, the separation of *luma* and *chroma* provides a histogram construction or thresholding rules using only saturation and hue. This works regardless of lighting changes in the value channel and practical clustering gives reasonable efficiency. The unsupervised clustering method uses for the purpose of the project is K-means clustering. It efficiently provides the ROI cluster from the thermal image which initials the particle filter for tracking these regions in order to automatically detect and monitor the hot spots.

B. Particle filter

Finding the hotspot looks easier as compare with updating the thermal increases and thermal region expansion within the time. There is a necessity for tracking the hot spots on the surface of body and having confident outcome regarding not losing the ROI location. Moreover, tracking algorithm must have reasonable robustness against uniform surfaces.

This approach uses a particle filter tracker [11, 13] to track and adapt on the tracking problem. It provides suitable condition to change the ROI during the video sequences. The particle filter has been used in many tracking purposes in the object recognition and similar applications on video processing [11-13].

There are some assumptions consider for the tracking algorithm as follows:

-The analysis of the thermal tracking takes place in the false colored images from having intensity of 0 to 255 corresponding for each color(however clustering is done in HSV color system);

-The ROI is always in the field of view (FOV) of thermal camera;

-Temperature of the ROI (subject) is higher than the surrounding environment (similar with real condition);

-The temporarily ROI is not in particular shape and must be adjusted through the algorithm; however the thermal increases (level of intensity) is an unpredictable contour shape having upward trend. The shape comprises the temporarily occlusion and other unwilling external factors influence the frame images e.g. motion artifact (the system is robust against motion artifacts);

- The ROI updates throughout the time of the experiment and temperature updates by upward trend to find the hot spots in the subject.

Using the proposed method as a tracking algorithm, particle filter works in the time t and approximates the tracking recursively target by a finite set of posterior distribution weighted samples.

In general, particle filters are the simulation class filters for approximation of random variables recursively. Let $\boldsymbol{\alpha}_t \mid \mathbf{Y}_t = (\mathbf{y}_1, \mathbf{y}_2, \ldots, \mathbf{y}_t)'$ are the random variables and $\boldsymbol{\alpha}^1{}_t, \ldots, \boldsymbol{\alpha}^M{}_t$ are particles having the discrete probability mass of $\boldsymbol{\pi}^1{}_t, \ldots, \boldsymbol{\pi}^M{}_t$.

Discrete points approximation of the variables shown by $\boldsymbol{f}(\boldsymbol{\alpha}_t|\boldsymbol{Y}_t)$ and for $\boldsymbol{\pi}_t^j$ are assumed to be equal $\boldsymbol{1/M}$ which desired amount of $\boldsymbol{M}$ for the particles to approximate the density of $\boldsymbol{\alpha}_t|\boldsymbol{Y}_t$. It is noticeable that the particles are locates in the ROI which is previously defined and incrementally updates throughout the thermal experiment. It gives an approximation for density prediction by particle support and empirical prediction

$$\hat{\boldsymbol{f}}(\boldsymbol{\alpha}_{t+1}|\boldsymbol{Y}_t) = \sum_{j=1}^{M} \hat{\boldsymbol{f}}(\boldsymbol{\alpha}_{t+1}|\boldsymbol{\alpha}_t^j)\,\boldsymbol{\pi}_t^j$$

A mixture of echoes while the filtering work and densities till producing up to proportionality,

$$\hat{\boldsymbol{f}}(\boldsymbol{\alpha}_{t+1}|\boldsymbol{Y}_{t+1}) \quad \propto \quad \hat{\boldsymbol{f}}(\boldsymbol{y}_{t+1}|\boldsymbol{\alpha}_{t+1}) \sum_{j=1}^{M} \boldsymbol{f}(\boldsymbol{\alpha}_{t+1}|\boldsymbol{\alpha}_t^j)\,\boldsymbol{\pi}_t^j$$

This is an approximation to the true density filtering. New particles produced $\boldsymbol{\alpha}_{t+1}^1, \ldots, \boldsymbol{\alpha}_{t+1}^M$ with weights $\boldsymbol{\pi}_{t+1}^1, \ldots, \boldsymbol{\pi}_{t+1}^M$ and this iterates through the data. This includes the online tracking problems and estimation of the one-step-ahead density $\boldsymbol{f}(\boldsymbol{y}_{t+1}|\boldsymbol{Y}_t)$ which here is very much relevant to update in the ROI and the spreading the hot spots within test [11-13].

III. Experimental and Simulation Results

This approach applied followed by the proposing a method for heating spots detection in the infrared video stream. The main part of the approach is related to computer programming modification and simulation on image analysis. The results of the proposed approach are revealed by the analysis in the model situation for benchmarking. The experimental results extensively reveal the effectiveness of the proposed method and robustness against any possible movements.

A. Experiment on the hot spots tracking

The mentioned analyses for finding the suitable fabric which has reasonable thermal properties is done to find appropriated gown for the patients. The fabric can be offered to be used as gown for some medical applications. It provides more reliable thermal and machine vision situation to observe the hot spots for prevention of the possible burning during the exposure. For this aim, an experiment has been conducted by the authors. The procedure of the experiment looks similar the position of the patients. The experiment is done by six participants. The experiment has done in the room temperature due to have more thermal similarity with actual situation. Each participant just wore the gown which made by the selected fabric and lied down on the

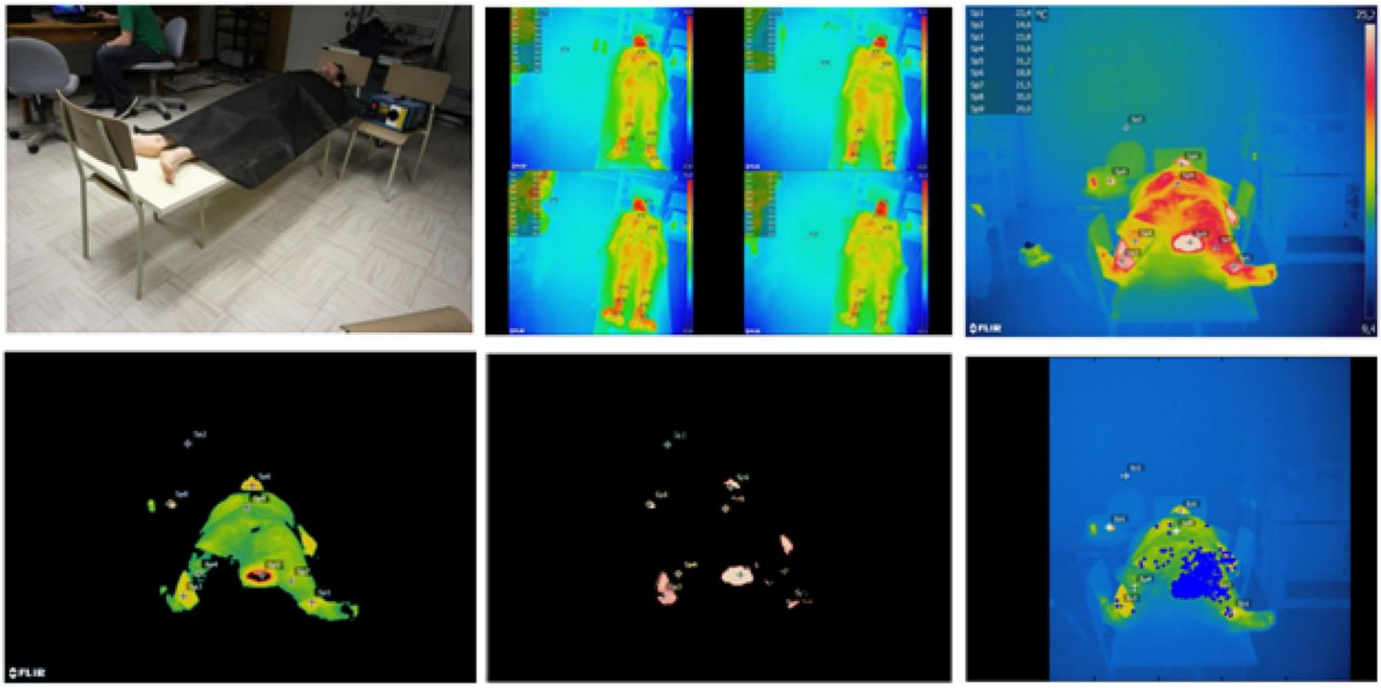

Figure 1. The figure presents the results of the segmentation for different clusters. The image at upper-left side reveals the visible image of a participant; upper-middle and upper-right images show the original IR images taken with FLIR (A65). The lower-left and lower-middle images are shown the different clusters. The lower-right image demonstrates the particle tracking results for heating tracking in the video stream. The selection of the human body in the IR-image using some other methods like active-contours involve the system into several unnecessary morphological operations but it is a suitable technique for tracking as well. However, implying the k-means clustering is seemingly faster as compare and reasonably accurate.

bed made for the experiment. The IR-camera is located in front of the bed and the distance of the camera and its angle was similar to the actual situation. Every experiment longing around 11 minutes and JENOPTIK and FLIR recorded the thermal variations. For simulating the hot spots in the surface of human body, a controllable heating element has been used. However for simplicity of the implementation and simulation the feeling heat temperature has been chosen around 55◦C. The blackbody also has been utilized as a reference and has been set for the temperature of the human body in the normal situation (around 37◦C). The blackbody located next to the subject bed and in front of the IR camera. The controllable heater took several minutes to reach the certain temperature and during this time all the thermal variations have been recorded accordingly. The heater is located closed to the subject gave more similarity to the real condition.

B. *Results of the tracking*

In this section, the result of the proposed approach presents for tracking hot spots in video stream. But the approach divided into several sections and each section has its own task. The k-means cluster has used to find the ROI which contains human body region having thermally higher intensity as foreground and compare with background where lower temperature (background) has. As k-means clustering is an unsupervised learning procedure so there was no training set has been used for the approach. The thermal video sequence was 30 frames per seconds which is high for the actual purpose of the approach. It is because of slowly changing process in the thermal variations. Due to the mentioned fact and having low computational complexity, the system considered one thermal frame processed per second. The sampling could be even lesser but applying particle filter required stepwise variations to have efficient tracking. The size of the thermal images for every frame was included 560*640 pixels and it has false color to have better visual discrimination of the heat. The clustering gave the ROI that includes human subject region in thermal image. It gave hot spots which are the targets for being tracked throughout the test. Particle filter provided a very good tracking outcome within the video. The particles created for tracking the hot spots are very much spread throughout the human subject which gave possible point of heats where were not feasible to be visually found but in numeric and quantitative analyses these point have hot spot temperatures. They gave the reason for been found by the particles. Therefore, the particles concentration has higher and more stable heating temperature that were constantly tracked by the particles and provided the accurate detection within the thermal images sequence. The unstable heating points were not continuously track by the particles and just temporarily detection which vanished over the sequences. The figure 1 reveals two images taken during the particle tracking in the IR images. The approach had reasonably responded on the all the subjects tried for hot spot tracking. The hot spots have been tracked during the whole thermal video sequences which represented efficiency of the approach in tracking the thermal changes within the actual situation. It is noticeable that the subjects were having slight movements in the streams and particles cloud track them. This results indicate the robustness of the approach against any movement and particularly motion artifact which is common problem in the medical tests.

IV. Conclusion

The presented approach addressed an automatic system for detect and track the thermal fluctuation that can be occurred in the medical examinations. It applied HSV based k-means clustering which initialized and controlled the points which lie on the ROI boundary. Afterward a particle filter tracked the targeted ROI during the video sequence. The proposed approach has been tested during some experiments and under almost similar circumstance. There were six subjects have voluntarily participated on these experiments. For simulating the hot spots occur, a controllable heater utilized near to the subject bodies. The results indicated promising accuracy for the proposed approach in tracking the hot spots. However, there was some approximation done regarding the transmittance of the atmosphere and emissivity of the fabric which can be neglected because of independency of the proposed approach for these parameters. The approach can track the heating spots efficiently however it can be done for the moving subjects as well which provide considerable robustness related of the motion artifact occurs during the medical test. As the future work it can be more scrutinized and even possibly more experiments can provides more concrete outcome gives confident regarding the method. The internal heating and its external effects needs further attention for future work of this research.

Acknowledgment

The authors would like to thank Matthieu Klein from Visiooimage Company at Quebec City for his helps. This research project is done under Chaire de recherche du Canada en vision infrarouge multipolaire (MIVIM).

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