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Development of Patient Motion Tracking System during Radiation Therapy

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Abstract

Assuming that the posture of patients is fixed until the completion of treatment only with confirmation of treatment site before the treatment due to the network of radiation therapy system, there is a concern that radiation dose may be administered into a normal tissue rather than a lesion. To continue to observe the motion of patients that might occur during treatment, the system to detect the motion of patients was developed through leveraging the high-definition video camera, C++ programming language and open CV with 2-evolution technique and BLOB technique. The reproducibility of patient posture was very practical since it allowed us to evaluate the change in the posture of patients in real-time by acquiring video in real-time during the treatment. It is essential to develop a system to detect a motion that may take place voluntarily and control the treatment equipment by tracking the motion of patients in a stable and natural posture suitable for the location of treatment. The purpose of this study is to contribute to the implementation of precise radiation therapy by developing a system to consistently observe the motion of patients based on the aforementioned technology.

Keywords: BLOB Technique, C++ Programming Language, Patient Motion Tracking System, Radiation Therapy

1. Introduction

Radiation therapy has achieved a significant breakthrough for treatment equipment with the advent of computer, precise control engineering, mechanical engineering and network. Data transmission between simulator, treatment planning system and linear accelerator is conducted via online. The system to confirm treatment sites for the last time can be verified through monitor unlike the past method that used film. The wedge filter used to change radiation distribution was replaced by virtual wedge. The shielding block that prevents an administration of radiation into normal tissues was changed to multileaf collimator. However, there have not been a lot of efforts to develop a system to monitor the motion of patients during treatment. On that account, precise radiation therapy might rather cause an irreversible side-effect. That is to say, assuming that the posture of patients is fixed until the completion of treatment only with confirmation of treatment site before the treatment due to the network of radiation therapy system, there is a concern that radiation dose may be administered into a normal tissue rather than a lesion. The purpose of radiation therapy is to kill cancer cells by concentrating radiation dose on the site requiring radiation. To this end, the International Commission on Radiation Units and measurements (ICRU) recommends to deliver radiation dose within ±5 percent[1]. To secure such level of accuracy, many scholars have conducted a study on the reproducibility verification system of various patient postures. For instance, some studies compared Digitally Reconstructed Radiography (DRR) reproduced from computed tomography image with portal image (Figures 2 - 5). Some studies compared portal image with radiation penetration image (Figures 6 - 8) and used portal image (Figures 9 - 11). However, the aforementioned studies are not able to detect the motion

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of patients that may take place during treatment by using portal image that was taken before radiation therapy. It is only possible to achieve the objective of treatment by administering radiation precisely with precise treatment plan. However, many cancer patients are an old-aged patient. Also, the degree of pain is severe. Thus, a motion can take place unconsciously during treatment. Such motion was verified only when a wedge filter or shielding block was replaced during treatment. In recent years, there is a risk of overlooking the task of confirming changes in the posture of patients since they were replaced by virtual filter and multileaf collimator. Thus, the purpose of this study is to contribute to the implementation of precise radiation therapy by developing a system to consistently observe the motion of patients.

2. Materials and Methods

This study utilized High-Definition Video Camera (HDCAM-1600UVC, KRIZER, KOREA) in order to develop a patient location tracking system (Figure 1). This study utilized Visual C++ and Open CV as programming language. This study utilized the BLOB technique that binds those groups having the same number by attaching the same number (label) to all adjacent pixels and a different number to different properties after binarizing with 0 to 255 value based on the threshold value with an image of 0 to 255 gray values. The process of patient motion tracking system is as follows.

1. Get the initial image by capturing an image from the camera. (Set and adjust the threshold and BLOB value to get the desired screen and group when receiving the initial image by pressing the preparation button).

- BLOB value has a larger designation group range with a higher value.
- Noise will be reduced with an increase in the threshold.

2. Obtain the central coordinates of each group by creating adjacent pixels and group having the same number as the BLOB value after binarize the captured image with the threshold value.
3. Select the number of group (BLOB) to be tracked.
4. Pressing the capture button will enable you to track the central point of corresponding group and moving beyond the reference point based on the number of accuracy will generate a shutdown warning window and signal.

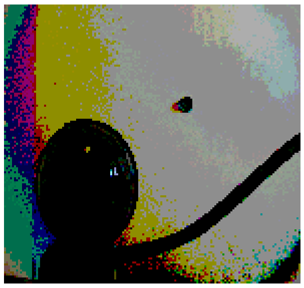

Figure 1. High-definition video camera (HDCAM-1600UVC, KRIZER, KOREA).

Figure 2. Initial screen of location tracking system.

3. Results

The patient location tracking program using high-definition video camera is operated in the following order. First, it receives an image according to the timer and then saves it in the memory. It selects an image through the labeling and then undergoes the process of calibration that maps the pixel value with the error value. After then, it calibrates the center point of BLOB in the selected labeling and stops the timer and removes the memory by deeming an object to have moved when the coordinates are moved. That is to say, it generates a signal that can stop the system by reacting to the motion of a target after designating surrounding image and other targets. Each program cording and result is as follows.

1. Get an image according to the timer.

```
void CCvcamTestDlg::onCapture()
```

2. Save it in the memory.

```
if(capture)
cvGrabFrame(capture);
frame = cvRetrieveFrame(capture);
```

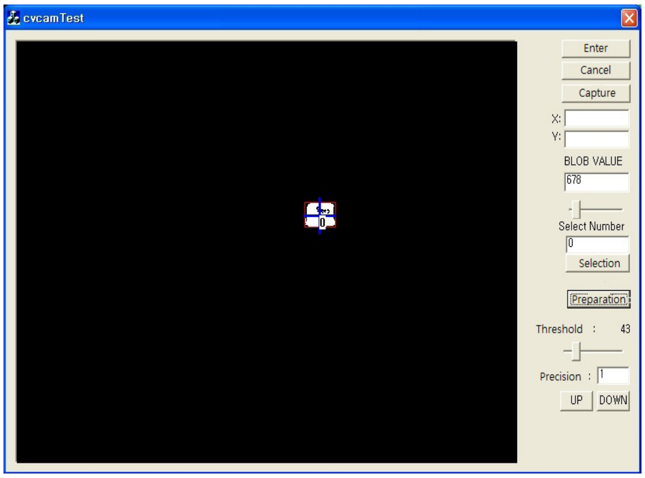

Figure 3. Marker perception

3. Set an image to express the label result.
frame_gray = cvCreateImage(cvGetSize(frame), IPL_DEPTH_8U, 1);
frame_threshold = cvCreateImage(cvGetSize(frame), IPL_DEPTH_8U, 1);
temp = cvCreateImage(cvGetSize(frame), IPL_DEPTH_8U, 1);
cvCvtColor(frame, frame_gray, CV_RGB2GRAY);
cvThreshold(frame_gray, temp, m_valslider, 255, CV_THRESH_BINARY_INV);

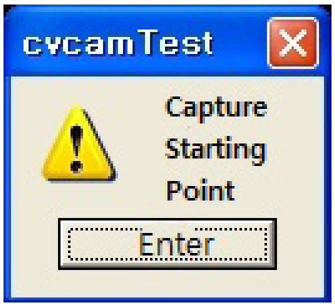

Figure 4. .Notification window of starting point calibration

4. Labeling
labeled = cvCreateImage(cvSize(temp->width, temp->height), 8, 3);
cvCvtColor(temp, labeled, CV_GRAY2BGR);
5. Set an image and minimum number of pixels for labeling.
blob.SetParam(temp, m_blobValueMain);
6. Conduct BLOB on the selecting labeling.
blob.DoLabeling();

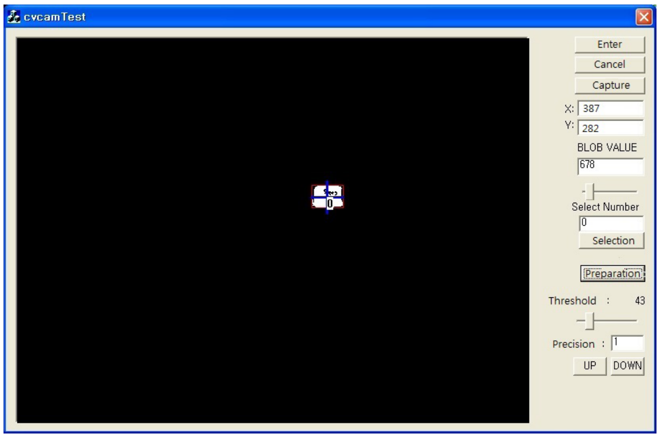

Figure 5. Figure to show the tracking of marker motion

7. Set the center of BLOB and deem the object to have moved when the coordinates thereof were moved.
CvPoint pt1, pt2;
for(int i=0; i < blob.m_nBlobs; i++)
pt1 = cvPoint(blob.m_recBlobs[i].x,
blob.m_recBlobs[i].y);
pt2 = cvPoint(pt1.x + blob.m_recBlobs[i].width,
pt1.y + blob.m_recBlobs[i].height);
if(m_start)
if(m_Selection = I)
8. Stop the timer.
CvScalar color = cvScalar(0, 0, 255);
cvDrawRect(labeled, pt1, pt2, color);
break;
9. Generate the screen.
else
CvScalar color = cvScalar(0, 0, 255);
cvDrawRect(labeled, pt1, pt2, color);
if(labeled)
Draw_Capture();

Figure 6. Notification window for capturing motion

10. Remove the memory.

```
cvReleaseImage(&frame_gray);
cvReleaseImage(&frame_threshold);
cvReleaseImage(&frame_hsv);
cvReleaseImage(&temp);
```

4. Conclusion

The system to track the motion of patients using high-definition video camera is as important as the automated radiation therapy system. This is because the purposes of radiation therapy are to concentrate radiation only on cancer and minimize radiation dose administered into normal tissues. A secondary factor for cancer might be caused if a large quantity of radiation is administered into normal tissues by a voluntary motion of patients during treatment based on precise treatment plan. In recent years, the tracking technique of cancer by inserting a marker around the image induction radiation therapy and cancer is being utilized. However, image induction radiation therapy is not able to detect a motion during treatment. Rather, it can only verify the posture of patients before treatment. In addition, the cancer tracking technique should insert a marker during surgery. Thus, it cannot be leveraged for those patients who cannot undergo surgery or whose cancer cannot be completely removed. It is very important to use an immobilized device that can stably fix the posture of patients. However, this method cannot be applied to all patients either. Therefore, it is essential to develop a a system to detect a voluntary motion and control treatment equipment by tracking the posture of patients in a stable and natural position suitable for treatment location. The equipment used in this study was the high-definition video camera. However, it is expected that more advanced patient motion tracking system, such as program using infrared sensor and infrared cameras, will be developed.

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