An assessment of video capturing outcome on six different grip models of camcorder using computer aided motion analysis

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Abstract

Movement analysis is the method which common in use recently to evaluate the motion object. In this study, laser light which was controlled by subject from the model pursued the chaotic motion target which was projected from the PC to the screen. Both data of two moving object velocity and distance of laser light were examined in spite of time response also taken into account. Six models of camcorder with different feature of grips were investigated. Eight right handed subjects handled and controlled the grip to track the target through laser light which was beamed from the laser pointer attached to the model. Both movement laser light beamed and target were recorded and acquisitioned using computer aided motion analysis into offline tracking. The results demonstrated that different shape of grip affected the time response of laser light when pursuing the target. Grasped grip with CCD camera angle adjustment and ball shape grip were indicated have a lack of response during the task performed and revealed long distance tracking. Not all size and shape of grips were suspected contribute the lost tracking. The different arrangement of view finder and CCD camera in the model might affect to the torque and influenced an operator to manipulate the control.

Keywords: Movement analysis, moving target, tracking, grip evaluation

1. Introduction

Motion analysis is become a method which useful to be applied in many area of scientific fields at recent. Basically, individual position of moving objects is identified and acquisitioned using visual motion analysis into an image sequence (E.H. Hayden and Y. Koike, 1972). Regarding the ergonomic evaluation of product design, this method also could be applied to observe the interaction between user and product. This method becomes an important factor in many fields with various applications (Frischholz, 2001). In the field of video making, capturing image is the component which influences the result of recording. It was suspected that holding video camera clearly demonstrated the relationship between the way of handling and capturing moment through the view finder. Evaluation of grip design constitutes an essential component of ergonomic evaluation, but still need in depth investigation to decide the proper grip design that fit to the hand control comfortably. In the principles of efficiency, both the grip design and handling method can be considered as a factor which causes the time response to capture the moment through camera view finder. This paper aims to asses the outcome of video recording through the proposed camcorder grip design using motion analysis method.

It is mentioned in the previous study that the grip design has influenced the task performed during handling (Jung and Halbeck, 2005). Due to the camcorder handling, inconsistence the velocity and direction of the moving object is the more difficult to be captured than object still. Regarding the nature of handling camcorder, upper limbs perform a significant role to orient the camera to track the motion object. The objective of this preliminary study was to identify a poor design of grip from the view of ergonomic principles and to develop a recommendation of the proper grip design. In this study, raw video data was analyzed using computer aided motion analysis.

2. Method

2.1 Subjects

Eight subjects of six males and two females (right handed type) participated in this study. All subjects are student of the university and they gave informed consent prior to the experiments which is indicated have no serious upper extremity musculoskeletal disorder.

2.2 Equipments

During the test, subject was asked to stand 230 cm in front of the screen (800 mm x 1000 mm) while holding the proposed model (Figure 1). Subject rested the right palm and fingers wrap naturally around grip. The total weight of each model is standardized (450 g) and each model was designed to accommodate the additional devices included Charge Coupled Device (CCD) camera (80 mm x 30 mm x 30 mm) and Liquid Crystal Display as a view finder (80 mm x 70 mm x 20 mm) within various configurations. Both devices were used to be a basic arrangement for each model during hold the task (Figure 2). The display was connected to the video signal processing Casio TFT Active Matrix EV-550 SR/NTSC.

PLUS 03-1100Z data projector projected the object target movement as a target from PC and then target was pursued by laser light as a tracker. The diameter of target was standardized 70 mm in a white circle. The object was programmed to hold still in 10s and then moved for 20s in chaos condition (Figure 5). Laser light was generated from the commercial laser pointer and attached to the model close to the CCD camera compartment. The laser light was projected into the screen and resulted a 7 mm on diameter in red color.

Tests of various models of camera grips were carried out and classified into different contours and shapes. All models were made of soft material and applied with the ballast to acquire a proper weight. Five models and a real commercial camcorder were evaluated which each model has a different way to hold (Figure 3) described as follow:

1. *Pistol grip model*. CCD camera was placed right over the grip and view finder was positioned in the hind of the model.
2. *Grasped grip model with grip angle adjustment*. This was a commercial camera Victor GZ-MC200 which able to be rotated to adapt the nature of the operator's hand motion from a grip in the side place of the camera. This model already brought a built in CCD camera and view finder.
3. *Diagonal grip model.* It was located under view finder and CCD camera. The handgrip was 24^0 of hand pronation with respect to the midposition.
4. *Grasped grip model with CCD camera angle adjustment.* CCD camera compartment positioned over the grip and able to be twisted diagonally to allow the wrist minimize the over adduction.
5. *Long cylindrical grip*. CCD camera was positioned over the view finder. Both devices were positioned in the left side of the grip.
6. *Ball shape grip*. The diameter of the grip was 75 mm. CCD camera was positioned over the view finder. Both devices were placed in the left side from the grip.

Videotaping the movement of target and tracker object used commercial digital video camera Victor VU-X9KIT (JVC) during the total of 30s in each experiment. The limit of video rate was set at 720x480 pixels for maximal quality of video resolution at sampling rate 29 Hz. To hold the steady position, camera was mounted on the tripod approximately 45^0 at 1.5 m from the screen.

WINanalyze version 1.3 video motion analysis program, developed by Mikromak GmbH, was used automatically to extract trajectories of object movement appeared in the sequences display.

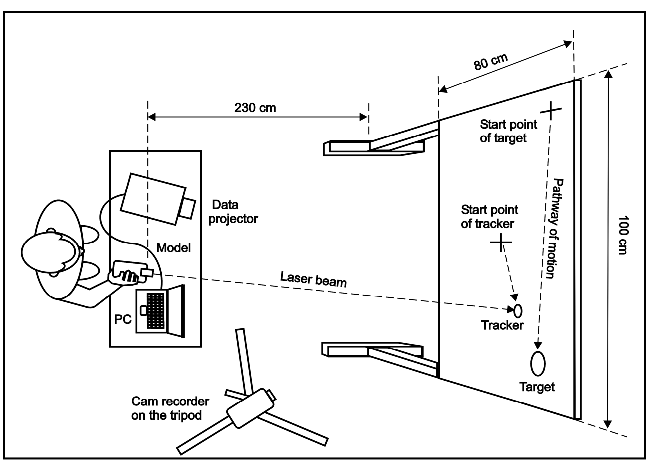

Figure 1. Illustration of the experimental set up in laboratory

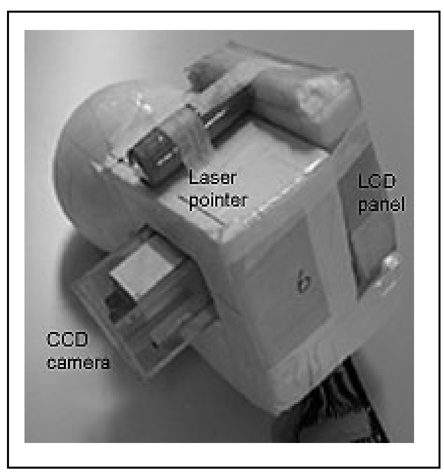

Figure 2. An example of ball shape grip configuration of laser pointer, LCD Display and CCD camera attached to the model

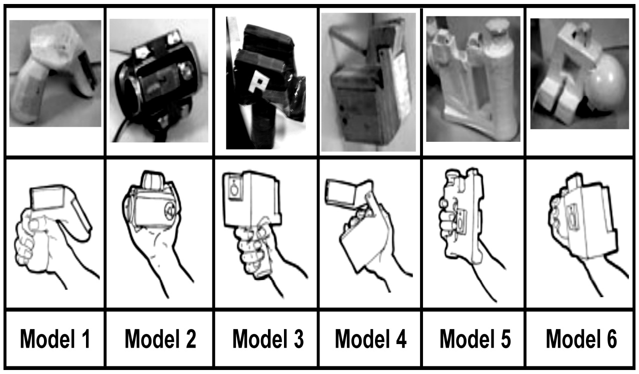

Figure 3. Six types of proposed model and accompanying sketch about the ways to hold the unit.

Based on the image processing calculation, point location of the moving object can be determined within sub-pixel accuracy (Frischholz, 1989). Each object position was determined in physical unit (mm) of every image sequence or frame. In this study, we try to concentrate on qualitative detection, no longer determine only the movement of a single object point, but calculate motion fields of compound object (target and tracker).

2.3 Procedures

A whole measurement and data processing procedure was carried out in these following steps:

1. Video tape recording of the moving object in the laboratory

Subject completed a total of four handling tasks in random order during a session approximately 30s with 2 min rest periods between trials. Subject was asked to orient the grip therefore the subject's wrist can remain in the most natural position while applying force and following the motion target as a guidance input in the screen. Object target positioned on the top-left of the screen standardized and subject positioned the object tracker in the center of the screen inside the circle mark as shown in Figure 1. The task was pursued the object target through tracker projected by laser beam and oriented the tracker as close as possible to the target during movement. Subject controlled the laser light movement from the view finder which attached to the model. Moving target which defined as a reflective marker are detected and tracked by certain algorithm system filtered through texture tracking method. This method was capable to track the moving object which has defined as a marker during recording the image sequence. Tracking method was conducted separately into offline (after recording) tracking.

2. Transferring data to PC as AVI files from the camera.

WINanalyze require BLD file format that store image sequence. Another file such as AVI file format also compatible to be analyzed. A video overlay board Ulead Video Studio 9 was used to convert analog data to be AVI format. The video camera was controlled by this software, which stops the videotape at the desired video frame, and allows for selecting and clicking point locations on the editing board.

3. Extracting calibration coordinates.

The frame rate of AVI file was 29 frames/s. In order to acquisition process, these files then were converted into 24 bit true color of its size from 720x480 pixels. For 30s recording with 29 frames/s of scanning rate, each trial result approximately 900 frames extracted by WINanalyze. An object with known dimension was used to be a reference for calibration frame. In this measurement, we used the length of screen 100 cm long. This method allowed to gain the online measurement therefore calculation and data processing can be conducted after recording and should not bring the PC on location (Frischhloz, 2001).

4. Coordinates from the objects positioned

XY coordinate data were extracted from videotape using an acquisitioning process described by Abraham (1987). Upper left display was set as reference coordinate (0,0). SSD-Correlation tracking algorithm was activated during acquisition to adapt the quality of image sequence which the color different has been taken into consideration. Almost all video data were not filtered and remain the original format.

5. Calculating distance and velocity of moving objects

WINanalyze allows the calculation to generate analysis windows, in which the object sequences of the current image sequence are displayed in diagrammatic form (distance, acceleration, and velocity) with respect to time domain or converting to the tabulating data which can be analyzed with other statistical program. In this analysis, both data of two moving objects distance were examined.

3. Result and Analysis

A few blur displays of data were found and can not be recognized easily during tracking. Under circumstances that the camera has a limit to capture the velocity of moving objects, due to not clearly visible and often difficult to be distinguished from environment surrounding. To improve un-acquisitioned object, High Pass filter was activated to contrast edges and corners of the objects. A few of unrecognized objects were acquisitioned manually.

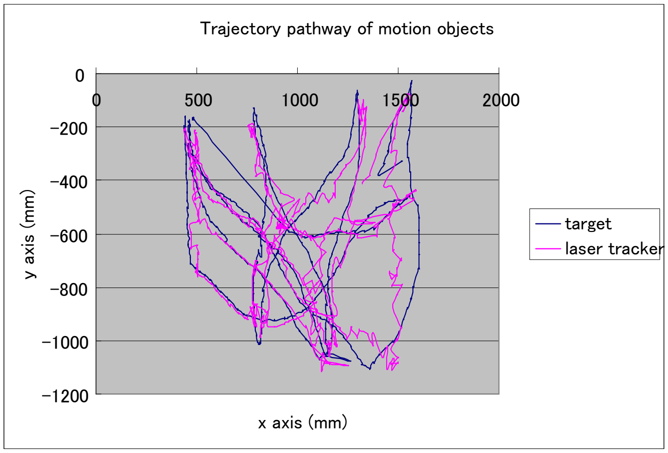

Figure 4. Typical trajectory pathway of motion objects projected in model 1 a pistol grip model hold by subject.

In the examination of the target motion and tracker projected, it is remarkable that the characteristics of both motion was clearly different. The typical data set consisting pattern of movement in one complete cycle of the movement is shown in Figure 4. The organization of the 2D target and tracker trajectory pathway is presented in the XY plane. As we expected, the motion objects revealed the different pattern among them as shown in the superimposed trajectory pathway of both objects. This typical result was found in all models tested. Laser tracker which pursued the target which moved inconsistence pattern was made. It was suspected that this pattern probably indicated that subject's hand was difficult on orientation and control the model in consistence. The pathway of laser light trajectories revealed the gap to the target's pathway as shown in Figure 5.

This condition may be influenced by the different feature of the model that employs the difference way to handle.

Lost of tracking was founded in a few frames during extracting video sequences. These possible sources of conditions were object was not clearly recognized and remained the distortion of object size in particular laser light. The method of fixing position coordinates was re-located the un-acquisitioned object and tracked manually for each individual image frame. For all movements performed by subject through laser light, the velocity of laser light tended to be faster then the target movement during task performed. This trend was most likely an effort to orient the laser light close to the target and remained the period of tracker response or time delay being occurred in motion. This tracking obtained two kinds of condition: tracker position left behind the object target and sometimes tracker position run ahead. Over all condition of tracking affected to the subject to response rapidly and resulted the velocity deviation 99.33 mm/s. Figure 6 demonstrate the pistol grip (model 1) indicated quite slow in velocity compared to the other models (mean: 694 mm/s) followed by grasped grip model with grip angle adjustment (model 2) in average 702 mm/s.

As mentioned before, both motion objects obtained the gap among them. The lack of subject's response affected the position misplace of tracker to the exact position of the target and produced the distance between objects which was one of the criteria to evaluate the proper design of handgrip. Figure 7 shows that each model revealed the different distance during pursued the target. Shortest distance was determined as the quick response of subject to control the laser close to the target. It was shown clearly that long cylindrical grip resulted

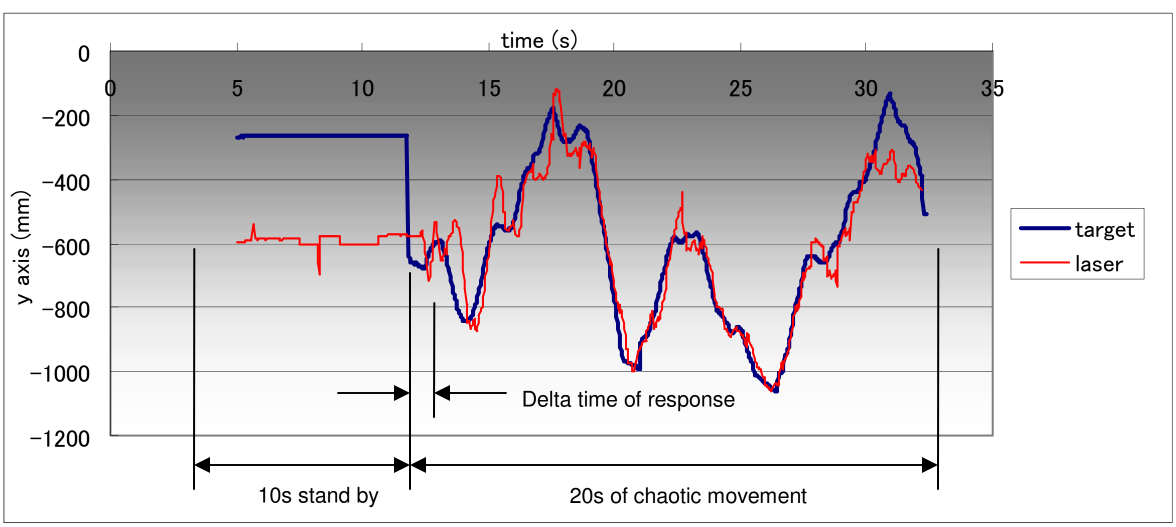

Fig. 5. Behavior of motion of both target and laser tracker which revealed a gap and time delay during acquisition.

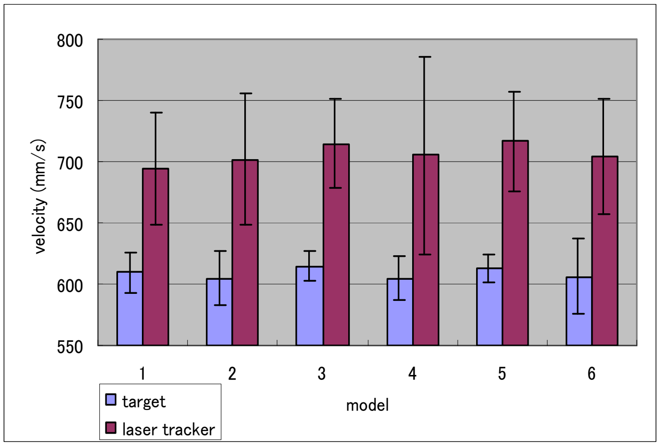

Figure 6. Contrast mean velocity (with standard deviation) between the target and laser tracker in all trial.

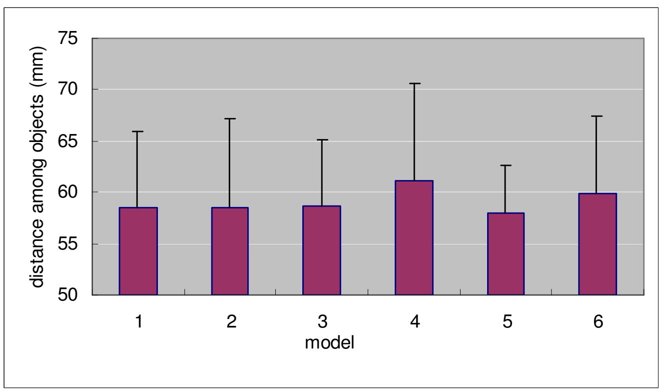

Figure7. Mean distance between the target and laser tracker in all trial.

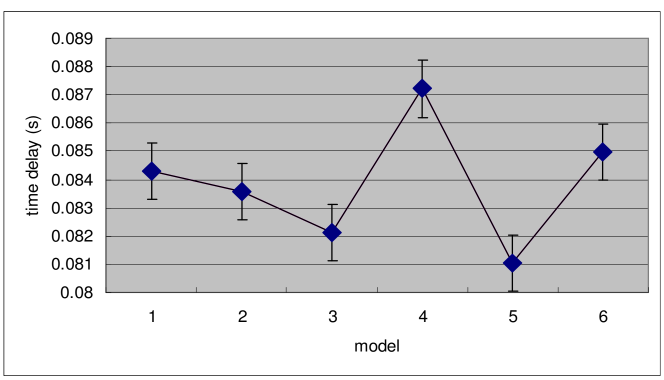

Figure 8. Time delay between the target and laser tracker in all trial.

57.96 mm (model 5) as a shortest distance among the models followed by grasped grip model with grip angle adjustment (model 2) in 59 mm. In contrast, ball shape grip (model 6) and grasped grip with CCD camera angle adjustment (model 4) produced a distance longer than other model.

There was a similar trend of both distance and time delay in diagrammatic form. In this term, time delay was define as the time it takes since the moment of target motion make a change in the control movement until a reaction or response was seen as a movement of laser tracker. In this case, the source of this time delay was the lack of physical handling response that may involve the transportation of laser light over distances. Illustrated in Figure 8, the comparison findings of all models showed that long cylindrical grip (model 5) contributed the average short time to travel the distance between two objects. As distance of movement, this model may have an advantage in controlling laser target but grasped grip with CCD camera angle adjustment (model 4) and ball shape grip (model 6) remained the highest time delay than other models.

4. Discussion and Conclusion

This study focused on the evaluation of the video camera grip design regarding the nature of tracking the object from the view finder using motion analysis method. Due to grip handling, behavior of the hand to control the laser light was taken into consideration. It was evidence from observation, there was a typical hand movement recorded during holding the model. It was noticeable that the characteristics of upper limbs body contributed the orientation the model. Shoulder joint was clearly observed to play the role of controlling the model frequently than wrist joint. Shoulder joint performed an adduction, abduction and flexion to hold the vertical movement of the target. Mostly, the hand hold the model performed in radial deviation then neutral position. It can be explained that the response of hand through laser beam tried to point the object target was slower than the movement of object target itself. The results demonstrated the different feature of grip mentioned in Figure 3 affected the time response of laser light when pursuing the target. The current data imply that grasped grip with CCD camera angle adjustment and ball shape grip were indicated have a lack of response during the task performed and revealed distance tracking longer than other models. It is important to be noted that the different arrangement of view finder and CCD camera in the model might affect to the torque and influenced an operator to manipulate the control. Target was pursued closely by tracker with long cylindrical grip followed by grasped grip model with grip angle adjustment. The experiments recorded tracker object often followed the object target left behind then position ahead.

Aligning the model's center of gravity with the grasping hand might affect the operator to not have to overcome rotational movement or torque of the model. We think a consideration should be paid as attention to the shape of grip which was compatible with the nature of motion of the operator's hand. However, we believe that most product are designed in a certain way to handle and might be affect to the habit pattern of operation that operator learned before.

Motion analysis, in this term of product design evaluation, is useful when operate automatically base on the capability of accuracy and efficiency. To do more efficient for its automation, make an active or online markers system and tracking-based system is preferable to reduce the time movement analysis and to avoid the risk of the lost tracking. Accuracy of measurement practically could be improved with the use of the advanced camcorder because the model of the Victor camcorder used in this experiment probably quite outdated and the picture quality produced is not enough high and often change itself on focusing object during videotape.

Regarding the study of ergonomics, it is often conducting user investigation by involving integrated measurement devices e.g. electrocardiography, electroencephalography, or electromyography more than the outcome of video capturing. Despite the findings in the present study, there is a need to confirm with another investigation to study in depth about the interaction between muscle activities of the upper limbs that might affect to the performance of grip handling. In addition, further study of muscle activity examination during holding task performance should be taken into account to confirm the effect of these various grips in trial. Motion analysis, when done automatically, avoiding the act of suffers from being ineffective and inaccurate and also from this study shows that the application of motion analysis method opened the opportunity to improve the quality of design.

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