Investigation of the Application of MediaPipe to Gait Analysis

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***Abstract*— The possibility of gait analyses using moving images was examined using the free software, MediaPipe. As a preliminary experiment for using this software in the rehabilitation field, we attempted a timed up-and-go test and confirmed that detailed ankle trajectories were obtained. In addition, considering the limitations of the camera installation during measurement, we examined the differences in camera position when capturing gait characteristics. As a result, the characteristics captured were almost similar, although some discrepancies were observed between the frontal image and data from the oblique direction. Detection of the ankle angle was possible. However, it is likely that the right ankle data will be calculated to be smaller, regardless of motion limitations, and a motion analysis using gait velocity will require the placement of objects for correction. If free software becomes available for motion analyses, it will be a turning point for the rapid spread of video analyses in the medical and healthcare fields, contributing to the collection of improved data through rehabilitation and daily health management.**

Keywords-gait analysis; MediaPipe; detection of ankle angle; health care.

I. INTRODUCTION

Health status is easily expressed during gait. In addition, functional impairment of the lower extremities can lead to serious accidents such as falls and tumbles. Falls and tumbling are common social problems. Among the lower limbs, the limited range of motion of the ankle joint can easily lead to stumbling and falling due to the inability to raise the toes. The measurement of lower limb function is useful in assisting the prevention of falls. Until now, medical and welfare professionals, such as rehabilitation and nursing care staff, have been responsible for providing support to prevent falls. In recent years, devices for measuring lower limb function have become widespread. However, the equipment used in rehabilitation medicine and sports requires detailed data and specialized knowledge of equipment operations. It is also difficult to make decisions related to health conditions in daily life [1]-[6].

Wearable devices are slowly being used in daily life. Simultaneously, they can provide information about a runner's running route and speed, as well as information about the body, such as the pulse rate. This information can be used as management records by connecting it to the Internet. Daily health-related data managed by servers can be very useful for elderly people. Internet of things (IoT) devices are developed in many aspects, however, practically, it is important to be able to accumulate daily health information even if the person is unaware of it. If an IoT device can measure ankle joint data, it can help prevent falls and stumbling. Previously, we measured the gait of dialysis patients, however, but the analysis required specialized knowledge of machine learning [7].

MediaPipe is free software from Google. Numerical data can be obtained using software related to faces that specializes in facial data and poses corresponding to the entire body. It is also possible to display Three-Dimensional (3D) skeletons from Two-Dimensional (2D) detection on the screen. The ability to see images of the skeleton as it is projected onto the physique is a point that is easily accepted in rehabilitation facilities [8].

This software provides 3D coordinates that increase its effectiveness. Specifically, if ankle angles could be obtained from images, it could be a promising alternative to the judgment of physical condition changes based on the experience of physical and occupational therapists. Long-term ankle angle data would also be useful for early detection of changes in physical condition due to illness or other causes.

Image-based video analyses have long been used in rehabilitation and other medical and healthcare fields, such as the joint research field, but it is very difficult and expensive to manage. Even if the equipment is useful, the number of people who can use it is limited [9][10]. If video analyses can be performed at a low cost, many people will be able to use it. Therefore, we examined the possibility of gait analyses by video using MediaPipe. If motion analyses

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become possible with free software, it may become a tipping point for the rapid spread of video analyses in the medical and healthcare fields.

All research members participated in the experiment and examined the analytical data. This research was approved by the Ethics Committee of Teikyo University of Science.

II. EXPERIMENTS

The subjects were two men in their 60s and 70s, respectively. The two gait events differed in terms of ankle restrictions. The supporter restricted ankle joint motion. In the case of the elderly patient experience set, the subject wore nothing but glasses, which did not restrict ankle joint motion.

The corresponding locations of the 33 landmark data locations on the body output by MediaPipe are shown in Table I.

TABLE I. POSE LANDMARK of MediaPipe.

Pose Landmark	
0. nose	
1. left_eye_inner	4. right_eye_inner
2. left_eye	5. right_eye
3. left_eye_outer	6. right_eye_outer
7. left_ear	8. right_ear
9. mouth_left	10. mouth_right
11. left_shoulder	12. right_shoulder
13. left_elbow	14. right_elbow
15. left_rwrist	16. right_wrist
17. left_pinky	18. right_pinky
19. left_index	20. right_index
21. left_hip	22. right_hip
23. left_hip	24._right_hip
25. left_kenn	26. right_kenn
27. left_ankele	28. right_ankele
29. left_heel	30. right_heel
31. left_foot_index	32. right_foot_index

For the evaluation of Comma-Separated-Values (CSV) data from MediaPipe, the same type of pressure sensors has already been used and reported, which changes the resistance depending on the pressure, ranging from 100 to 1MΩ [7]. A 1kΩ resistor was connected in series with this sensor, and the voltage change of the resistor was used as the input signal. Each sensor measures the voltage at 1kHz. Eight sensors were arranged parallel to the direction of travel. The pressure-sensor data were connected to an Arduino Mega 2560 R3 connected to a Personal Computer (PC). The connection between the sensors and the Arduino is shown in Figure 1.

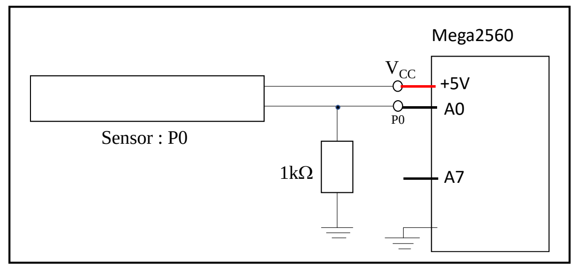

Figure 1. Connection of sensors and Arduino.

The output signals of sensor numbers A0-A7 and the distance between each sensor were used to calculate the walking speed.

A. Analysis of data obtained from MediaPipe

1) Accuracy check of CSV data outputed by MediaPipe

We investigated the possibility of using the CSV data output by MediaPipe to perform gait analysis using the elderly patient experience set. The measurement indicates how accurately the ankle position can be quantified. Because the analysis was performed during gait, we used images from the timed up-and-go measurement, which is used as a basis for the evaluation of falls in the elderly, for the analysis in MediaPipe.

Figure 2 shows the trajectory of the timed up-and-go measurement. The trajectory was similar to that of the left ankle. A detailed ankle trajectory is obtained. The video analysis of the timed up-and-go test confirmed that the maintenance of the integrity of the specifications [11]-[13]. Figure 2 shows the trajectory of the body relative to the gait site with a high degree of accuracy.

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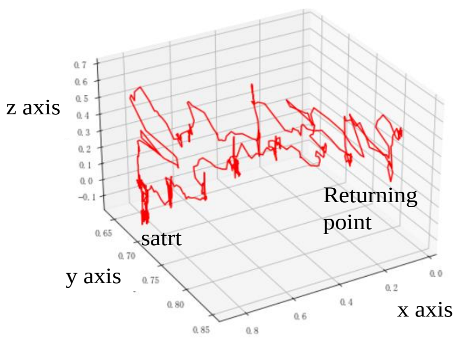

Figure 2. The trajectory of the time up and go analyzed by MediaPipe.

2) Results from the front angle

Gait videos taken from the front under two different conditions, one without motion restriction and the other with motion restriction by a knee supporter, were analyzed using MediaPipe. The left side of Figure 3 shows the image without motion restriction, and the right side shows the picture with motion restriction.

The values of z, which represent the height of the left and right ankle joints, were plotted against the presence or absence of motor restriction, respectively. The upper and lower figures show unrestricted and restricted motions, respectively.

Figure 3. The skeleton analysis of without/with restrictions using video from front.

The upper and lower figures show unrestricted and restricted motions, respectively.

The values of z in Figure 4, which represent the height of each the left and right ankle joints, were plotted against the presence or absence of motion restriction, respectively.

It can be determined that the time that the heel is on the floor is short because the average of the integrated values of the z values of the foot that is applies the restriction is large.

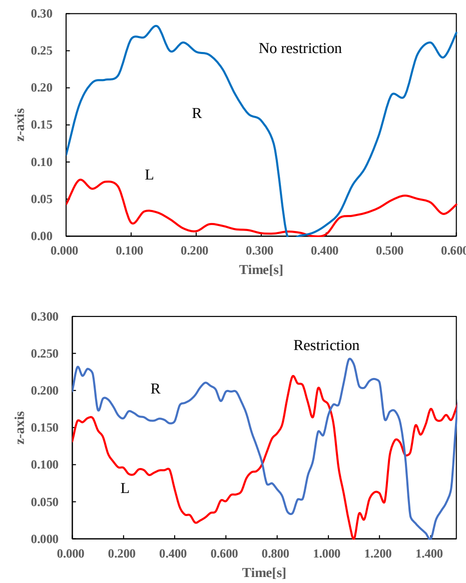

Figure 4. Values of z which represent height of ankle.

3) Results from an oblique upword angle

In this analysis, the image was taken obliquely upward, so it was enhanced by the effect of the z-axis length ratio. However, peaks corresponding to the left and right toes were also observed. Differences due to the angle of filming were analyzed from images obtained from the front and from diagonally above.

The left side of Figure 5 shows the image without motion restriction, and the right side shows the image with motion restriction. The sheet on the floor is the pressure sensors described in Figure 1 at the experiment.

Figure 5. The skeleton analysis of without/with restrictions using video from oblique upward angle.

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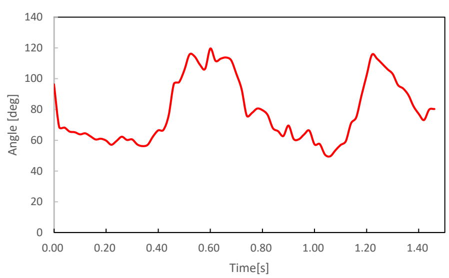
The separately conducted results of the ankle angle measurements indicate that the subject's left and right feet have different flexibility. This may have a significant effect on the gait. Therefore, we considered the ankle and knee and the ankle and toes as vectors and obtained the angle between these two from the inner product. Images were taken in two different ways while the subjects were walking and being analyzed.

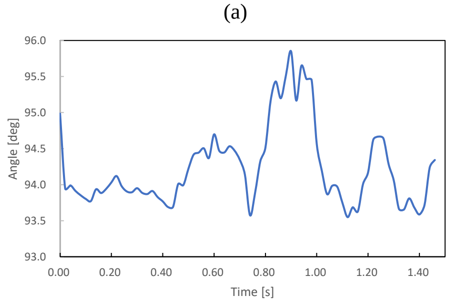
Based on these results, the ankle angles that significantly affected gait were determined. The results of the analysis are shown in Figure 6. The frontal view is used for images (a) and (b), and (c) and (d) are oblique images. Changes in the left and right ankle angle were almost identical with and without motion restriction. However, in both cases, the change in the right ankle angle was smaller. It is not clear whether this was a feature of the subject's gait or a software problem. Further studies are needed in another experiment with a different subject.

4) Gait speed

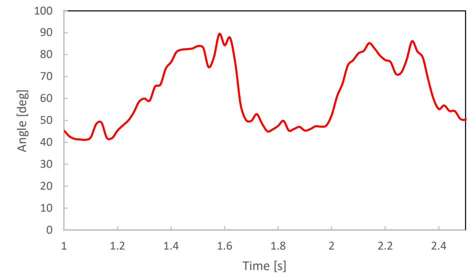
The gait speed was examined. As the coordinates are those of the projection from the camera, correction is necessary [14]-[17]. Although it is best to correct the coordinates from a 3D viewpoint, in this case, the correction was based on the walking trajectory. Therefore, we compared walking speeds based on measurements for which specific lengths were known.



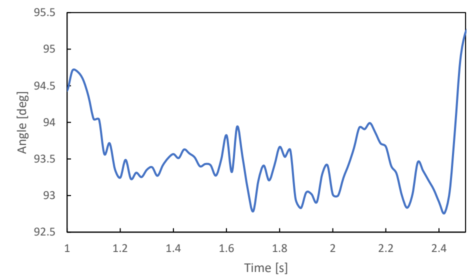
(a)



(b)



(c)



(d)

Figure 6. Results of ankle angle from the front and an oblique upward angle

As for gait speed, we also compared the data with the data from the pressure sensor and examined which points should be analyzed to obtain accurate based on the principle of the software. We determined that it would be difficult to determine the walking speed when shooting from an oblique direction because the screen is moved in an oblique direction. However, it was thought that data could be obtained for comparison if the same conditions were used. Clearly, the problem with images taken from the front was that the size of the subject varied depending on the measurement data point.

Therefore, we considered the part of the image that was considered to move as little as possible on the screen. In the present image, the shoulder area was close to the central part, therefore, we considered this point. In the walking speed obtained from walking on the mat, differences of approximately 2.1 km/h and 1.3 km/h were obtained with and without motion restriction, respectively. However, the values obtained from MediaPipe were approximately one order of a magnitude lower.

Thereafter, we plotted the data for y on the right shoulder, which had the largest slope. The right position of the shoulder as a function of time is shown in Figure 7. The obtained value was approximately 1/3 of the value. This point was examined as follows.

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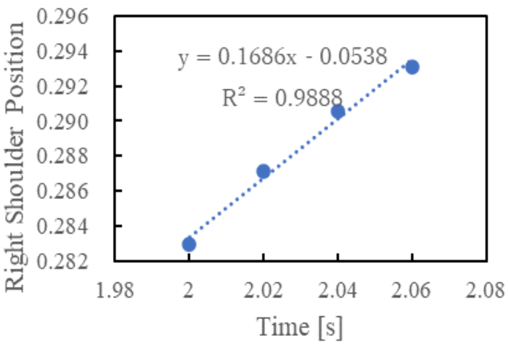

Figure 7. The right shoulder position as a function of time.

Figure 8 shows the 3D display of the trajectory of the right shoulder position. Because the slope of the change in the right shoulder position is almost 45°, it was found that using the correction value for the direction of motion on the screen, a walking speed of 0.4, which is almost the same as the 0.38 obtained from the mat, could be obtained.

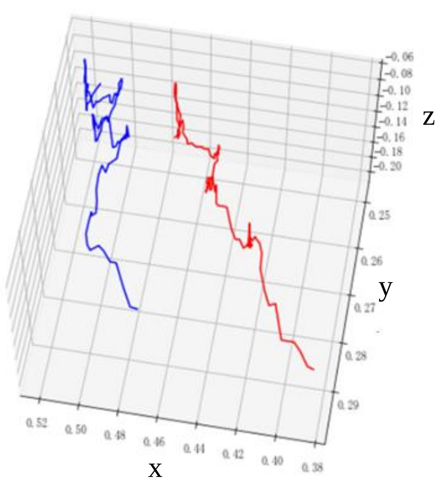

Figure 8. A 3D display of the trajectory of the right shoulder position.

The fact that walking speed can be corrected by selecting the detection point indicates that some ingenuity is needed, such as shooting parallel to the travel direction when capturing the video.

III. Discussion

The analysis using MediaPipe reproduced the left ankle trajectory in the timed up-and-go measurements as shown in Figure 2. The z-axis values corresponding to the vertical motion are small due to the screen settings; therefore, the z-axis values are emphasized. Consequently, it is necessary to make a prior reference measurement and correction for accurate evaluation. However, as shown in Figures 4 and 6, it was possible to determine the ankle angle as gait condition data, although we did not calculate this timed up-and-go measurement. Comparing the separately measured range-of-motion angle data of the ankle joint and comparative ankle joint range-of-motion angles obtained from the video, slight differences were observed due to the camera angles. The angular change in the right foot was almost the same, regardless of the camera angle. By contrast, the angular change in the left leg tended to be smaller. In the subject's gait, another measurement result showed that the joint change in the left foot was smaller than that in the right foot. It may be possible to analyze whether this is due to the subject's characteristics or the effect of the camera angle by changing the measurement conditions or by comparing the gait data on other subjects.

Because this software can be installed on tablets and smartphones, we believe we have shown that the skeleton analysis screen can be effective as a simple check at the rehabilitation site. In the case of a detailed numerical analysis, there are differences in the numerical values obtained due to differences in camera angles, necessitating the use of a camera with a sufficiently wide angle at the time of measurement or having the camera fixed to eliminate camera shake during movement. The current experiment only shows the results of the analysis of one subject with and without pseudo limitation of movement, and data from two subjects of different ages and genders measured simultaneously are currently being analyzed. Based on the above, we believe that the conditions necessary to use this software in the field can be determined by accumulating data and adapting it to subjects with gait disorders.

IV. Conclusion and Future Work

Today, with the widespread use of smartphones making it easy for many people to take videos, it is also easy to take a picture of a person's walking condition and ask a medical professional to diagnose the problem. The ability to obtain skeletal displays and numerical data, as with this software, is expected to rapidly improve the potential of video analysis in the medical insurance field.

However, the limitations of the shooting conditions when introducing this software should be considered. For example, it became clear that the shooting angle and which point the analysis should be focused on are important. We will improve the optimization of video shooting conditions and correction methods for all shooting angles. In addition, these corrections are made and adapted to the subject.

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