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ISC 4943 – Practicum in Scientific Computing

The Efficacy of Video Gait Tracking Software in the Detection of Abnormal Footfall Patterns Relating to Early Stages of Specific Neurodegenerative Conditions

Introduction

Though one may think of gait— the act of walking— as simply a tool to get from one place to the next, it can actually reveal an abundance of information about a person’s personality, the items they are carrying, their physical health, and even certain mental health conditions (Callisaya et al, 2017). Gait is evaluated using a number of qualities such as mean gait speed, mean step length, mean footfall time, and cadence (Demura et al., 2014). These parameters can indicate whether an individual is in good or poor health based on evaluations of normal ranges of each parameter found in previous research (Callisava et al., 2017). As one ages, a gradual degradation of cognitive and motor functions is common but can also be the first sign of an underlying condition that could require treatment (Demura et al., 2014). When the symptom of gait changes is in conjunction with a set of other symptoms affecting cognitive function, this may indicate the presence of one of several neurological conditions frequently found in elderly patients (Yang et al., 2020).

Dementia is an often misunderstood term that is frequently used incorrectly. Contrary to popular belief, dementia is not a disease in itself, but a syndrome. It encompasses a large set of illnesses relating to lowered level of function in the brain but is not deemed a diagnosis itself. Nevertheless, these associated symptoms are in fact used for the diagnosis of a number of neurodegenerative diseases. Some symptoms of dementia are loss of memory, lack of strong critical reasoning, inadequate self-care, loss of focus, and emotional irregularities. This is a direct result of neurons in the brain deteriorating, losing synaptic connections, and even dying. Dementia can range from mild to severe: from barely affecting daily function to complete dependence on others for basic maintenance.

Alzheimer’s Disease is a condition under the umbrella term of dementia that is more common in the late stages of life but also affects a portion of the US population under 65 (early-onset Alzheimer’s Disease). The majority of all dementia cases are diagnosed as Alzheimer’s; however, that is not to say that either of the two are a normal part of the aging process. The condition is marked by a significant change in memory, thinking, and behavior (Seifallahi et al., 2019). In short, it is theorized that Alzheimer’s Disease is a result of damage caused by the increased amount of amyloid plaques and the disruption of communication between neurons caused by an accumulation of Tau tangles. Though these proteins are found in healthy brains, in large amounts they can be extremely harmful. Researchers are still unsure of the reason as to why the amount of Tau and Amyloid proteins increase in Alzheimer’s patients, but it is theorized that it may come from a genetic mutation in the APOE gene.

As the disease progresses, the symptoms worsen and hinder the facilitation of everyday activities such as speaking, walking, and thought. Currently, there is no cure for Alzheimer’s Disease, but there are treatments to help alleviate the symptoms. It is extremely valuable to note that although there is no cure for Alzheimer’s, there are several treatments that can be utilized to slow the progression of the disease. Hence, there is a sense of urgency that is put into discovering Alzheimer’s Disease early and slowing the progression of the illness before it has advanced too severely for the mitigation of symptoms to make a substantial impact.

Another neurodegenerative disease closely associated with dementia, Parkinson’s Disease, also results in a marked difference in motor functions such as gait. Parkinson’s is most identifiable by the shaking of one’s hands or fingers and instability in walking (Sabo et al., 2020). Worldwide, more than 10 million people live with Parkinson’s Disease. It is mainly caused by the decrease of the neurotransmitter dopamine in the region of the brain that controls the initiation of certain motor functions, the substantia nigra. The low dopaminergic signaling causes a stuttering communication between the substantia nigra and the basal ganglia, which ultimately leads to choppy movement.

Parkinson’s increases the difficulty of performing simple tasks such as eating and drinking or traveling from one place to another, which can greatly impact an individual’s wellbeing. This condition does not have a cure and, unlike Alzheimer’s, there is no method of slowing the progress of the illness besides maintaining regular exercise and the intake of symptom-relieving medications (Seifallahi et al., 2020). There is much more to learn about Parkinson’s Disease, most prominently marked by the fact that researchers are still unsure about the true cause of the condition. However, an early discovery of its existence would still benefit the patient in that they would be able to know how to manage their symptoms before it becomes a larger obstacle to overcome.

While the most obvious symptoms of neurological conditions common in elderly patients are memory loss or confusion, difficulty with language or numbers, and mood or personality changes, another less obvious symptom of neurodegeneration is changes in gait (Demura et al., 2014). Specifically, in the case of dementia, Parkinson’s, and Alzheimer’s Disease, those suffering from these conditions have a slower gait speed, smaller mean step length, longer mean footfall time, and less fluid cadence when they walk (Callisaya et al., 2017). Through empirical research, studies have revealed evidence that these gait symptoms worsen in parallel with the progression of the neurological condition, though more research is needed to solidify the degree of the relationship (Seifallahi et al., 2020). Gait abnormalities also result in high risk for frequent falls and accidents that can cause serious injuries to elderly individuals (Yang et al., 2020).

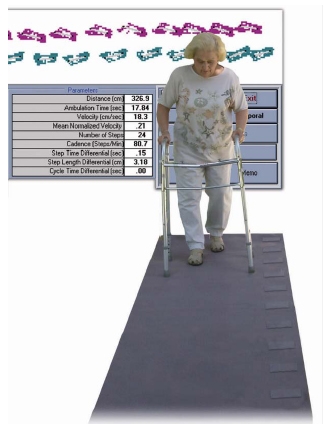
Conditions like dementia, Alzheimer’s Disease, and Parkinson’s Disease are more likely to first reveal explicit evidence of gait abnormalities as opposed to neuropsychological abnormalities (Yang et al., 2020). This is based in years of research, as it has been found that cognitive activities and gait functions are both processed with the frontoparietal network. Thus, when a person with one of these conditions has their frontoparietal network overloaded with both cognitive and gait tasks, certain facets of one of the two tasks are likely to become neglected. That is to say that the overburdened and impaired individual will fail to walk correctly, abandon the cognitive labor, or perform both endeavors with less proficiency. This can occur outside of dementia-related diseases. Because neuropsychological abnormalities expressed in behavior are much harder to identify, gait is a wonderful alternative for assessment.

These instances of mental overloading have been studied extensively by what is called a dual-task gait test, which is when researchers attempt to assess the extent to which an individual can handle this cognitive double-tasking in the frontoparietal lobe. In the case when a person unintentionally abandons the physical responsibility of retaining balance while walking, it becomes more likely for injuries to occur (Yang et al., 2020). These falling incidents can be extremely debilitating for the elderly and according to the CDC “are the leading cause of injury and death in older adults” (CDC, 2016). This means that gait screening could be a lifesaving tool for the elderly, even those without neurological conditions.

By conducting longitudinal studies of the gait of individuals with Alzheimer’s Disease in tandem with Dementia Rating Scale (DRS) evaluations, researchers have found evidence of a relationship between gait and Alzheimer’s (Seifallahi et al., 2020). In other words, as the participants’ gait worsened, so did their personal DRS score for Alzheimer’s disease. This means that if the relationship between gait and a neurological condition is somewhat linear, minor differences in gait could indicate early signs of a neurological condition that would otherwise be difficult to detect through other symptoms.

Early detection could result in a great number of positive results. It would lead to less chance of injury due to falling or accidents relating to lack of motor control caused by the early stages of Alzheimer’s Disease (Demura et al., 2014). The implications of the widespread use of gait tracking technology could help diagnose Alzheimer’s patients earlier, therefore granting opportunities to slow down the progression of the condition, allowing for easier daily functioning, and prolonging the patient’s life.

There are several methods to tracking the gait of individuals. Systems of sensors attached to a mat have been developed to track the pressure, location, and timing of each step that individuals take (Seifallahi et al., 2020). This allows for precision and accuracy in the measurement. Several systems employ this method, including the GAITRite Walkway and Protokinetics Zeno Walkway. The sensor mat is connected to a computer, which takes in the raw data and displays the results in a number of ways. The system displays where the steps were taken on the mat, the pressure points in each step, the distance between each step, and a recreation of the walking sequence as it was initially recorded. Data points pertaining to the timing of the steps and patterns relating to balance are also recorded.

 A picture containing text

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The Protokinetics Zeno Walkway and an example of data tracking.

The GAITRite Portable Walkway and an example of raw data tracking and measurements.

When using gait tracking mats for the purpose of indicating the onset of Alzheimer’s Disease, there are some downsides that occur as a result. Participants in the study would be elderly and many would not be able to walk in a straight line across a thin mat, which means that they would require assistance from another person or a walker. Though the software does have ways to delete the tracking of walkers, these assisting devices can still lead to inaccurate results or lack of results due to misplaced steps and the assistance given to get recordable data. If the measurable walking area were not limited, there could potentially be more accurate results because the participant would be able to walk in a much wider area without the need for assistance. In addition, the mat would not suffice as a suitable measurement tool for everyday practical purposes such as monitoring gait in a physician’s office because it would take too long and ultimately deviate from the original reason for the appointment with the physician. Finally, the method is not cost-effective, with several gait tracking mats costing over $20,000. This makes it unlikely that your average person would have access to gait tracking.

Hence, the reason for this research is to discover whether video gait tracking could be a potential alternative to tracking gait using mats. The video tracking would be cheaper in cost (Nieto-Hidalgo et al., 2018), and more representative of one’s natural gait. Most importantly, because of the ready availability of the devices needed to run the program, the video gait tracking system would be available to more people and easier to facilitate in an everyday setting, as more people have access to a camera than a gait tracking mat. People just beginning to show symptoms of a neurological condition would be able to receive treatment earlier than if their diagnoses were based on behavior alone. Additionally, the system could be modified to be used in a number of other medical areas that involve gait such as physical therapy, podiatry, orthopedics, and biometric analysis.

Computational Aspects

The project requires the use of deep learning to track the feet of the person who is walking. Visualization techniques will be used to mark the position of each step and to estimate the distance between them. To do this, a program will need to be made using the Python coding language and a number of tools that are available in the OpenCV, PixelLib, Numpy, Scipy, Matplotlib.pyplot, and other libraries. To track the position of the feet, one would first need to be able to indicate where the person is in the video.

Object detection and tracking has been a crucial discovery for innovations anywhere from medical imaging of malignant cell clusters to security and surveillance, and even to automated machinery and self-driving automobiles. While object detection is when a program is able to recognize where an object is in a photo, object tracking expands this idea to incorporate the identification of the object as it moves in each frame of a video. There are several advantages to object tracking as opposed to object detection, which will be discussed in greater detail below. The concepts of object detection and tracking rely heavily on the broader field of computer vision.

Computer vision involves the training of computers to view and understand the space visible to them through some sort of recording mechanism. This can be in the form of a regular camera, infrared camera, UV camera, or other device. This allows the analysis of an array of different categories of data using computer vision methods. In essence, the goal of computer vision is to allow computers to interact with the world using human-like perception and, in some cases, understand even what may be invisible to the human eye. In this study, computer vision will play a crucial role in the discovery of whether gait can be accurately perceived by video tracking enough to make conclusions about gait-related neurological conditions.

OpenCV is a free-to-download library that works with several languages including Python. Though there are several functions, the main element that was used in this study was the object tracking feature, as opposed to the object detection tool. There are two major advantages to using object tracking methods instead of object detection. Firstly, object detection faces each individual frame with no prior knowledge, while object tracking uses preceding data to predict likely positions of the target. Because an abundance of information is given in the previous frame of a video, object tracking tends to run faster than object detection systems. Secondly, since an object is not likely to move extremely far from its last position in the previous frame, object tracking better estimates the target's new position, even when obstructions are present. OpenCV was a powerful tool that allowed this project to be completed within the given timeline, as creating these tools would have been a research topic in itself.

After the location of the person is identified and recognized by the program, this information will be saved. The analysis will be done frame-by frame using a black and white segmented version of the image. OpenCV will be used to perform both tasks- the conversion of the video to black and white and segmentation. Using a binary thresholding algorithm, the original video in color was converted to black and white. Black and white photos keep the important skeletal data but remove extraneous details. The algorithm worked by categorizing each pixel either as white or black. Because each pixel can have a value from 0 to 255, the threshold was set as white (or 0) for values equal to or under 127 and black for values over 127. This binary threshold was accessed through OpenCV’s ‘THRESH\_BINARY’. The thresholding to create a black and white photo was done to each frame, or the entire testing video.

In an attempt to achieve the greatest accuracy, there was an additional, simpler tool that was used to compare with the previous example using OpenCV. PixelLib is a free tool that utilizes the Xception training model, the COCO dataset, Pascal VOC, and Mask RCNN. It should be noted that PixelLib also uses OpenCV methods, such as cv2, only less explicitly. The Xception system is a deep neural network architecture created by Google researchers. Depthwise separable convolution involves the use of both depthwise convolution and pointwise convolution. In its original form, the first mentioned convolution proceeds the second. This, compared to conventional convolution, is much more efficient because the number of connections are fewer because the convolution is not conducted between all channels. In the Xception model, this process is modified to have the pointwise convolution first and the depthwise convolution second. When compared with other models, Xception seems to perform with higher accuracy than many, but is very expensive to train. By using transfer learning, this problem is solved because the pretrained models are saved and uploaded to be used for many purposes. The COCO dataset – where coco stands for “Common Objects in Context” – is a large object detection dataset that was used to detect objects in the videos. Pascal VOC helps to build algorithms for object detection and segmentation. Mask RCNN helps to predict a mask for all detected objects. Together, these tools work together to detect an object in an image or a video.

Using a repository of lateral walking data, it will be possible to detail the location of the person with great precision and accuracy. The concept of using established data to help this program accomplish these computer vision identification tasks is called training. OpenCV has object detection systems that allow one to track objects such as limbs that protrude from a central location, including details as minute as individual finger positions. By training the program to know where a person’s legs and feet are, would be less likely that the program will fail to recognize the target feature that we wish to extract in our video- the feet. Ultimately, it could be used as a tool to reduce error in the estimation of the target’s position in each of the frames of the video. However, the implementation is not established and may require more time to execute than is available during the practicum.

Segmentation, as mentioned previously, is another process that will aid the computer in reading in the video data. This method uses thresholding techniques such as k-means clustering in order to simplify the image. The simpler an image gets, the less likely the computer is to make a mistake. Yet this has to be personally tested before moving on with the study because the image will reveal little information if it is too simplistic. Therefore, the researcher must see the results with their own eyes to see if there was an under or oversimplification of the individual in the video. If the background is considered to be underrepresented, that may be fine, even if the measurement marker- which will be discussed later- is not able to be seen because the original video file should always be saved and the modified video should be exported as a new file.

Then, the program will need to be able to track where the person’s feet are in the frame. By implementing this same method for the legs and feet of the person in the video combined with trained systems to detect where people are in a frame, there should be a clear indication of the step’s location and its duration. To calculate the length and time of the step, it will be necessary to first pinpoint when the foot hits the ground. However, the step time could also simply be measured by using time measurements and the maximum width of the individual in the video during a single step. Either way that it is approached, the measurement would be best accomplished if the video is taken from a lateral angle showing the side of the individual (Adeli-Mosabbeb et al., 2012; Nieto-Hidalgo et al., 2018). To also permit correct scaling, the background should have some indication of length that demonstrates a specific distance such as one foot. This can be any measurement as long as it is specifically stated either in the video or documented elsewhere.

By using the marker, a ratio is created that can be applied to any other measure of distance in the photo. This way, the camera can be set up at any angle where the marker is visible and still receive valid data. However, this means that the camera would have to remain in place throughout the duration of the recording, otherwise the marker ratio would have to be constantly recalculated. Luckily, this would not be an issue for the majority of situations where the camera position is initially established in one place. The distance marker would be measured by the pixel length, then compared to the number of pixels in the object one wishes to measure. Then, if the ratio scaling of one meter is equal to 100 pixels, an object 50 pixels wide would be about half of a meter wide in reality. This distance measurement will be crucial in estimating the gait variables such as gait velocity and average step time.

Since this research is dependent on a multitude of measurements, an operationalization of each term is needed to avoid confusion and increase replicability. A step would be defined as the position in which a foot is fully contacting the floor and is finished in its forward movement. This would be the moment before an individual begins to lift their foot off of the ground in preparation for another step. A goal of this project is to highlight these specific steps in the program to create a replication of the full recorded walk. This will be done by placing a series of markers indicating where the steps were taken. To discover other more obscure but inherent properties of gait, other key features will be measured. Mean gait speed, mean step length, mean footfall time, and cadence are among these elements. These properties are similar in nature and utilize many of the same variables but have their own formulas for computation.

To calculate the mean step length, one would evaluate the distance from the beginning of the back step marker to the beginning of the front step marker. To calculate the mean footfall time, one would need to calculate the average time it takes for the individual to take one step. In addition, the mean gait speed would be evaluated by finding the average distance that the individual travels per second. These values will be compared with the true values of each measurement to see if the video gait tracking system is accurate in the estimation of gait parameters. The true measurements will be determined by personally looking at the video and timing. Finally, these differences will be evaluated in order to see if the program would be able to detect small variations in step timing variables.

To understand gait, there are some properties and terms that must be defined. The gait cycle consists of the stance phase and the swing phase (Uustal, 2014). There are five stages to the stance phase when walking: the heel strike, the loading response, the midstance, the terminal stance, and the pre-swing. In addition, there are three stages in the swing phase: the initial swing, the midswing, and the terminal swing. During these stages, the phrases single limb support and double limb support will be referenced. In essense, the two terms reveal whether the bodyweight was being reinforced by one or two legs. Each stage in the stance phase will be defined, followed by terms in the swing phase.

The heel strike stage is when the foot initially contacts the floor. Ideally, the hip should be flexed at thirty percent, the knee should be extended, and the ankle should be perpendicular to the leg. In this stage, the body has support from both the front leg and the back leg. In the loading response stage, the hip is still flexed, but the knee bends and the foot is parallel to the ground. This is a crucial time in the walk cycle to absorb the weight of the body mostly on one leg in preparation for the single leg support in the next stage. In the midstance stage, the hip moves to under the body and the secondary leg moves forward. As previously mentioned, full bodyweight is supported entirely by the one leg. During the terminal stance stage, the hip moves backward and the secondary leg continues to move forward. In addition, the ankle is once again perpendicular to the leg. Finally, the pre-swing stage is when the primary knee tucks in slightly and prepares for the load to be switched to the other leg (Uustal, 2014).

In the swing phase, each stage is defined as single support. This swing phase occurs directly after the stance phase. The first stage, the initial swing stage, requires a certain amount of coordination, as the swinging foot needs to clear through both the other foot and any materials in the environment. In this stage, the knee is bent and the foot is lifted, bringing the leg forward underneath the hips. During the midswing, the leg is brought forward in front of the body and the knee is beginning to straighten. At this point, the foot is parallel to the ground. Finally, the terminal swing involves the straightening of the knee, the forward movement of the leg, and the positioning of the heel toward the ground. After the terminal swing, the cycle repeats again at the initial contact when the heel touches the ground.

A diagram of a human body

Description automatically generated with low confidence

The results during each of these stages could determine the ordinariness or abnormality of the walking patterns of an individual, potentially revealing an abundance of information about the state of that person’s health. Because the single support stages require a sense of balance, those struggling to support themselves or taking longer in these stages could be at risk of falling. Especially as one ages, the muscles begin to deteriorate and may not be able to withstand the full load of the bodyweight. However, those who are within a healthy body weight and have a normal amount of muscle mass may show signs of struggle during these periods in the gait cycle if they are within the boundaries anywhere from mild to severe cognitive impairment. In contrast, because of this lack of balance, individuals may choose to take smaller steps. A shorter step length may also indicate cognitive impairment, as shorter steps do not require extended periods of stability.

There are several “normal” ranges for different variables relating to gait. The average gait speed is about two to three miles per hour. This equates to about sixty to eighty meters per minute. If needed, these numbers can be converted to other units of measure depending on the marker distance and the timing of the walk. Average cadence, or steps per unit of time, is about eighty to one hundred ten steps per minute. The average step length is about sixty centimeters. Moreover, there are ratios that are considered to indicate typical walking patterns. The ratio of time in stance and swing phases should be around sixty to forty, and the ratio for single to double limb support should be about eighty to twenty.

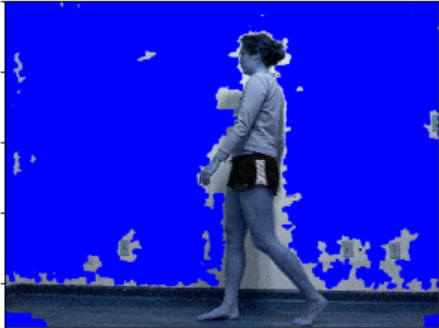
If time permits, I would like to be able to find video data on this subject and examine true dementia patients’ gait patterns to see if my results would be worth pursuing in the future. Because of my lack of resources and participants, this program could be seen as a preliminary stage to a larger goal of being able to use gait effectively to help others identify and battle their illnesses. The dementia research is being utilized as a method of determining how precise the gait parameters have to be in order to be useful in practice. Ultimately, this program could be refined and applied to a number of other areas besides Alzheimer’s and dementia research, such as security systems, public safety, identification, and beyond (Kwolek et al., 2019).

Results

Results from OpenCV:

A person standing in a room

Description automatically generated with low confidence



Removing the background from the image with OpenCV.

A person singing into a microphone

Description automatically generated with medium confidence

Image with body highlighted (obvious problem with the flooring)

Results from PixelLib:

A silhouette of a person

Description automatically generated with medium confidence

It was determined by looking at these pictures that PixelLib was the optimal method of determining the gait parameters, as there were fewer problems with background disturbance. To test true gait patterns, other case study trial videos of individuals with Parkinson’s were used and segmented using the PixelLib method. A step happens at the widest point, as the front foot surpasses all other segmented parts of the body at the front, and the same for the back foot. Therefore, at the widest point, is the step length. This measurement can be used to conclude the average stride length. In addition, if timed from the moment from the smallest width to the largest width within a given time, the step time can also be concluded.

The individual frames were segmented, then run again with overlay set to True in order to get an image that dimmed both the segmentation and the original picture so that both could be seen at the same time. Three examples are given below of the same frame in the three stages of segmentation. The videos were extracted from Youtube and were marked as case studies of individuals with a number of conditions effecting mobility. In this case, the man featured below suffers from Parkinson’s Disease, though the severity is unknown.

A person standing in front of a whiteboard

Description automatically generated

A silhouette of a person

Description automatically generated with low confidence

A picture containing player

Description automatically generated

A picture containing player

Description automatically generated

Distance of step displayed at this moment.

Another program was made using the TkInter library and the Pillow library, with the goal of finding the distance between two points. The program was designed to measure the Euclidean distance from a first left click of the mouse on a specific position of an image to a second left click of the mouse on another area of the image. A two-sided arrow in the last picture represents where one would click in order to measure the distance of the step. A third click was used to display the distance recorded. This was mainly used to get the pixel distance from a marker put on the floor that would be used for the estimation of the distance.

The distance, when calculated by eye, was about three feet in length. When recorded by the program, the step resulted in a 185 pixel length for this step, with the entire step taking 20 frames. This method is highly dependent on the frame rate of the video and the quality of the camera. If each pixel measured one centimeter, depending on the use of the marker in the recording of the gait video, that would mean that this step would be recorded as 185 cm. During the course of this video, as there were 300 frames that took a total of 20 seconds, the frame rate was 15 frames per second. This means that the step time was 1.25 seconds.

When the values for each step are measured and collected, the average value of all steps is the average step time. To compare, I used a video of myself walking. When compared to my own gait speeds, there is a clear difference in stride length and average gait speed, but these differences could also be explained by my height and a youthful gait and potentially not just a neurological condition alone. Ultimately, there would need to be more data collected of individuals around the same age as the dementia, Alzheimer’s, or Parkinson’s patients before coming to conclusions about the comparison. However, this does show that the tool could be useful to accomplish this goal in the future with modifications.

Analysis of project with milestones and timeline

The project will require many weeks of work and may need to be modified in order to fit the timeline of the practicum. As an entire tracking program must be made, I intend to use certain packages and libraries to speed up the process. OpenCV will be the main library that will drive forward the research. This is a visualization tool that incorporates a number of camera and video friendly features that will prove to be helpful in gaining information during this research. In the first week, I conducted research on the topic of gait tracking and more specifically gait tracking footfall patterns in reference to its relationship to Alzheimer’s, Parkinson’s, and dementia.

Additionally, in the first week I was working on the draft of the project proposal, which is the document that was submitted prior to this current document. The research paper will then be sent to my advisor, Dr. Wang, for review. The week after, I planned on revising the project proposal with the advisor’s suggestions in mind, making changes that are necessary for a good grade in the course. It was determined that I needed to include the references’ citations where the information was being used. This was all that was completed before the first document.

In the previous stage, I had some new tasks that were not foreseen when I was first planning to conduct this research. In the fourth through sixth weeks, I was working on the program itself and this first report draft. During this time, I came to the conclusion that it was essential that I use some premade library for object tracking, as this would take an abundance of the research time if I were to create the program from scratch. Luckily, I found OpenCV and created a basic object movement tracking program that is able to outline a person in a video with a box and save that data. I planned on having the tracking of the individual done in my program by the sixth week, but I still need to segment the image because at this moment the individual is only outlined by a box that touches the outermost portion of the person.

After the sixth week when the draft was returned with revision instructions, I made the necessary changes and continued to add content to the report. I aimed to include screenshots of my own program’s results in the proceeding draft. By the eighth week, the goal was to have the segmented image foot tracking portion and the highlighting effect of the program completed. By the 10th week, I planned on having the program completed and the final bugs fixed. During the eighth through 11th weeks when the second draft was due and returned, I began to write the report and justify whether or not the results support the hypothesis that the video gait tracking is a precise and accurate enough tool to use to detect signs of early onset Alzheimer’s Disease, Parkinson’s, or dementia by examining a patient’s walking qualities.

Finally, during week thirteen, I plan on finalizing my report and finishing any work that was left over from the previous weeks. During this week I plan on also creating the draft for my oral presentation and then finishing the report to turn in by the end of the fourteenth week. I will try to get this done ahead of time so that I have time to revise any confusing language or include information that may be helpful to the full understanding of my report. Perhaps if the presentation is before the due date of the report, I will be able to incorporate any feedback I get from the attendees into the revision of my final draft of the research paper.

Possible Shortcomings and Future Improvements

The program was first designed to track the gait parameters automatically, but this proves to be a task that cannot simply be solved with one semester of work. For this reason, the distances between the steps had to be measured by manually looking through the segmented video data. Though this method is somewhat costly, it does accomplish the task it was sent out to achieve. Ultimately, it could be used, with some refining and additional research data, to discover insights about gait that are not perceptible by the human eye. Therefore, I believe that video gait tracking will prove to be the force that drives forward the future of Alzheimer’s, Parkinson’s, and dementia’s research and diagnosis.

Though the idea of the early detection of such debilitating neurological diseases through a cost-effective and easily-implemented method sounds ideal, it is also crucial that one would not be losing key pieces of information about an individual’s gait patterns by employing this method. There have been great advancements in video tracking technology; however, there remain several disadvantages in choosing this method. While there are similarities between the two methods in detecting measurable distances and timing data, there is no current method for accurately estimating the pressure that one takes for each step through video analysis or tracking. The pressure on the foot during a step provides a key factor that indicates whether or not an individual is balanced while they walk. Uncoordinated and unstable walking leads to higher risk of falling or injury, which, again, has dire consequences especially for the elderly.

In addition, the video quality will play a critical part in whether the data collected is accurately representing the true gait properties of an individual. Therefore, high quality and high frames per second cameras will be necessary to ensure correct results. Consequently, this may result in a decrease in accessibility because of the steep cost of this quality of camera. Although adequate cameras do generally cost less than the high price of the gait tracking mats, there still is room for improvement to ensure that more people have access to this potentially lifesaving screening. It is my opinion that in future research there should be an emphasis placed on the comparison of the quality of different affordable cameras such as the Microsoft Kinect camera in detecting qualities of gait.

Lastly, in the future I would like to incorporate a method that allows these measurements to be recorded automatically as the participant is walking, as well as test different camera qualities and whether PixelLib is able to accurately record the movement despite the blur. If this were to be used frequently in a physician’s office, the automation would be extremely important. Doctors and nurses have their own work at hand and would not have time to perform many iterations of simple calculations. This implementation is highly feasible and could be done by saving each width into an array and calculating each step as the greatest width of the highlighted portion before the measurement starts to decrease again, signifying the beginning of a new step.

Conclusion

Overall, though studies begin to reveal more and more information about the relationship between gait and neurological conditions and neurodegenerative conditions such as dementia, Alzheimer’s Disease, and Parkinson’s Disease, it becomes increasingly essential to channel the effort into providing accessible and affordable methods to identify and combat the illness in itself. Especially because there is a severe lack of information about how it starts and what can be done to effectively and permanently heal those suffering from these ailments, having a way to identify the problem as close to its genesis as possible may be the best alternative to a cure.

Citations

Adeli-Mosabbeb, E., Fathy, M., & Zargari, F. (2012). “Model-based human gait tracking, 3D reconstruction and recognition in uncalibrated monocular video.” Imaging Science Journal, 60(1), 9–28. https://doi-org.proxy.lib.fsu.edu/10.1179/1743131X11Y.0000000002

Callisaya, M.L., Launay, C.P., Srikanth, V.K. et al. “Cognitive status, fast walking speed and walking speed reserve—the Gait and Alzheimer Interactions Tracking (GAIT) study.” GeroScience 39, 231–239 (2017). <https://doi.org/10.1007/s11357-017-9973-y>

Centers for Disease Control and Prevention (CDC). “Falls are leading cause of injury and death in older adults”. CDC.gov. (Sept. 2016). https://www.cdc.gov/media/releases/2016/p0922-older-adult-falls.html

Demura T, Demura S, Uchiyama M, Sugiura H. “Examination of factors affecting gait properties in healthy older adults: focusing on knee extension strength, visual acuity, and knee joint pain.” J Geriatr Phys Ther. 2014 Apr-Jun;37(2):52-7. doi: 10.1519/JPT.0b013e318295daba. PMID: 23835771.

Kikkert L.H.J., Vuillerme N., van Campen J.P., Hortobagyi T., Lamoth C.J. . Walking ability to predict future cognitive decline in old adults: a scoping review. Ageing Res Rev 2016;27:1-14. https://doi.org/10.1016/j.arr.2016.02.001

Kwolek, B., Michalczuk, A., Krzeszowski, T., Switonski, A., Josinski, H., & Wojciechowski, K. (2019). “Calibrated and synchronized multi-view video and motion capture dataset for evaluation of gait recognition.” Multimedia Tools & Applications, 78(22), 32437–32465. https://doi-org.proxy.lib.fsu.edu/10.1007/s11042-019-07945-y

Nieto-Hidalgo, M., Ferrández-Pastor, F.J., Valdivieso-Sarabia, R.J., Mora-Pascual, J., García-Chamizo, J.M. "Gait Analysis Using Computer Vision Based on Cloud Platform and Mobile Device", Mobile Information Systems, vol. 2018, Article ID 7381264, 10 pages, 2018. https://doi.org/10.1155/2018/7381264

Sabo, A., Mehdizadeh, S., Ng, KD. et al. “Assessment of Parkinsonian gait in older adults with dementia via human pose tracking in video data.” J NeuroEngineering Rehabil 17, 97 (2020). <https://doi.org/10.1186/s12984-020-00728-9>

Seifallahi, M., Soltanizadeh, H., Hassani Mehraban, A. et al. “Alzheimer’s disease detection using skeleton data recorded with Kinect camera.” Cluster Comput 23, 1469–1481 (2020). https://doi.org/10.1007/s10586-019-03014-z

Uustal, H. “Normal Gait”. Prosthetic/Orthotic Team at JFK-Johnson Rehab Institute. (2014). https://medicine.missouri.edu/sites/default/files/Normal-Gait-ilovepdf-compressed.pdf

Yang, Q., Tian, C., Tseng, B., Zhang, B., Huang, S., Jin, S., Mao, J. “Gait Change in Dual Task as a Behavioral Marker to Detect Mild Cognitive Impairment in Elderly Persons: A Systematic Review and Meta-Analysis.” https://doi.org/10.1016/j.apmr.2020.05.020.