Artificial Intelligence Assisted Mobility Device Development

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Gifted Gabber

ABSTRACT

Artificial intelligence is rapidly gaining attention in the world for assisting humans with tasks that they could not achieve otherwise. In the medical industry specifically, artificial intelligence has made it possible to almost connect the original human body with another perfected body. This paper is intended to summarize the different conditions that may lead to someone needing a mobility device in the first place, what companies have preexisting parts that we can repurpose for the ideal artificial intelligence assisted mobility device, and the different AI technology that we can use to build this machine. The main methods utilized to collect the data used in this paper were collecting research from various scientific journals on the different conditions that can lead to the need for a mobility device, data collected from medical technology companies, and research on different artificial intelligence tools. Combining these pieces of research from different scientific journals and technological sources, it was found that the leading causes of falls are a result of cognitive impairment and balance-related issues. It was also concluded that the main pieces of equipment, are already present and would need to be manufactured in a way that the elderly user could use it on a daily basis. The overall research concluded to find that the artificial intelligence device would need to be flexible, durable, and greatest of all, prevent the user from falling or alarm a medical professional that someone is at risk of falling.

Introduction

Every year, around "one-third of persons 65 years of age or older fall each year." This often leads to people falling more often—specifically, "the risk doubles or triples"— and their mental and physical health is compromised. These falls can ultimately lead to "cognitive impairment," or even death. There are several medical devices out there that can assist elderly people in countering their likelihood of falling. However, in real time, the results of these medical devices include several failures. These machines are not able to support these senior citizens: they don't have enough flexibility or the machine is not able to prevent their falls as accurately as necessary. Such can be determined by the data collected on the number of falls recorded annually by several medical companies.

Incorporating artificial intelligence into the mobility devices that already exist would allow us to predict when patients would fall, rather than leaving it up to the elderly people to balance themselves and correcting their stride. If we are able to attach AI-powered devices to preexisting mobility devices, these AI devices could predict when there are slippery areas (areas in which there are liquids spilled on the ground in front of the people walking) or when there are steps (steps provide an obstacle for elderly people since they can only use railings to assist them, especially when there are no ramps nearby). Tracking these types of areas would allow the machine to alert the user beforehand that they were approaching an area that could pose a danger to their mobility, and allow the elderly person to orient themselves before approaching that area or avoid the area altogether. Artificial intelligence would also allow us to implement stability, chemistry, mobility, and flexibility into the machine. Currently, flexibility seems to be the most significant problem that is posed when considering pre-existing mobility devices; these devices are not able to connect directly with the user and help them move

as naturally as possible with support (i.e. stairs are difficult to climb even with the mobility devices with them). The research conducted below will address the different benefits and difficulties that are present in current medical mobility devices, and how artificial intelligence can enhance the mobility devices that are present in the medical world currently. In addition, it will explain the different common reasons that elderly people (or people of any age) typically fall and how the mobility device can aid them to prevent their preexisting medical conditions from worsening. Ultimately, the ideal artificial intelligence assisted mobility device will be produced from the various research conducted.

What Is Needed in The Mobility Devices

Main Reasons Elderly Citizens Fall

There are several different reasons why elderly citizens seem to fall, including common disorders such as obesity but also include more severe symptoms resulting from various diseases. The various connections to disorders and mobility issues are shown below.

Cardiovascular Problems

Cardiovascular disorders are the reason for over 50% of elderly citizens' reported falls. Most of these falls are attributable to a particular syndrome named vasovagal syncope, or VVS. According to data tracked by the University of Leicester, Glenfield Hospital, around 30% of people are likely to suffer from VVS sometime in their life. This syndrome is typically precipitated by the effects of "dizziness, nausea, diaphoresis, palpitations and chest pain," and can be caused by either emotional trauma or This syndrome can ultimately lead to falls or even loss of consciousness if not treated, which can lead to serious side effects. This seems to be one of the major causes of cardiovascular-related falls, however, there are several other syndromes that can lead to major falls. These can be broken down into mainly three categories: neurally mediated syndromes, cardiac abnormalities, and miscellaneous. Vasovagal syncope falls into the category of neurally mediated syndromes, as the majority of the problems that vasovagal syncope creates are connected to the brain due to trauma. Additional syndromes, such as arrhythmias— including atrial fibrillation and 2nd or 3rd-degree heart block— can lead to side effects of dizziness or trouble walking in general, which can increase the likelihood of the person falling. Typically, these conditions are more likely to be present in elderly citizens, which is why the majority of the focus in the technology we need to develop will be focused on elderly citizens.

Typical symptoms of all cardiovascular disorders start with "obesity" and "diabetes mellitus," and are the result of "smoking." In fact, "over 60%" of the American population suffers from "two chronic health conditions" and are 65 or younger (younger than the typical age where diseases seem to be prevalent in human beings). These are called "multiple comorbid conditions," or MCC. The risk for MCC is only predicted to increase over time, leading to an increase in the necessity for health care. The current needs for health care are not being fulfilled because of society's lack of value in giving people who are disabled access to devices that would help them—to the point of people who need motorized wheelchairs not having access to them. The problem with the preexisting lack of access to technology for disabled people is that the need is continuing to grow for social change. If people continue to demonstrate early symptoms that will lead to cardiovascular disorders, they will likely also gain physical or mental disabilities, in turn leading to disabilities such as "gait disorders, musculoskeletal deformities and pain, and paralysis." Without access to even the basic machines that can aid physically disabled people, there will only continue to be a problem with the lack of access to health care and the lack of access to devices that can aid those who are disabled. To remedy this situation, not only does society need to find more value in providing aid to those who are disabled, but it is necessary to provide devices that can assist users with all of their potential disabilities (and side effects due to the disability).

To counter the problems present in elderly citizens through cardiovascular syndromes, we would need to be able to include any medical history into whatever device we were creating so that the device would be knowledgeable of how to assist the person to the best of its ability. Including heart monitors in the machine, or having some connection from heart trackers to the device, will help assist the user with any problems they may be dealing with due to cardiovascular issues.
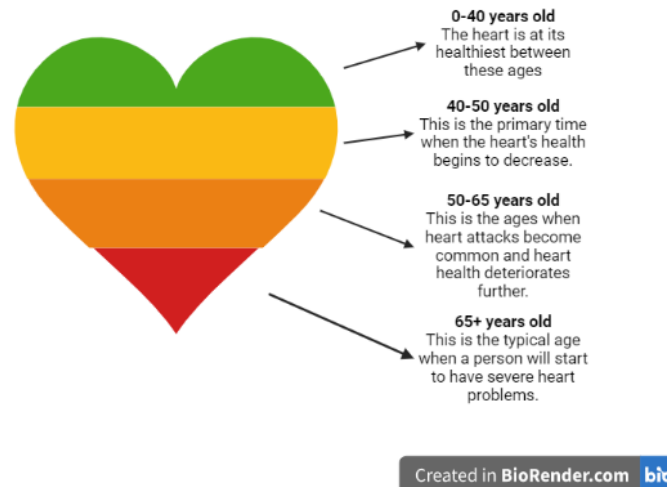

Figure 1. The Stages of the Heart As a Human Ages. This describes how the heart of children and young adults is typically healthy (as signified by the green and yellow coloring), but over time, the heart can reach a dangerous state (as signified by the red and orange coloring) and lead to serious conditions affecting mobility.

Mobility Devices Present Currently

There are several mobility devices that are currently present but may need some tweaking or adjusting in order to satisfy the requirements posed by people with different disabilities. To better evaluate these different preexisting devices, we can observe what the most credited medical companies are creating in regard to mobility devices.

Danaher

Danaher is a medical company that "specializes in blood gas analysis, transcutaneous monitoring, and immunoassay testing for cardiac, coagulation, infection, and pregnancy markers." As such, since this company does not focus greatly on mobility devices, it may seem as if there is no potential for us to utilize any parts of their technology for the ultimate AI-assisted mobility device. However, their technology that is focused on cardiac testing could potentially provide use in our mobility device.

Danaher's cardiac-related machines, specifically a new device called AQT, an immunoassay analyzer, allow medical professionals to run "critical cardiac tests" in closer range "to the bedside in emergency departments and intensive care units." Suppose these tests can be automated, or some of the technology or programming can be taken out and employed in the final mobility device. In that case, these cardiac tests could assist the user in checking if any abnormal heart problems are present, or if the heart rate is increasing abnormally. It is known that around 77% of people are likely to fall due to "cardiovascular disorders"—at least for the people who are "presenting to Accident and Emergency Departments with unexplained or recurrent falls." As such, implementing technology that can test for cardiac-related problems is an essential part of creating a technology

that can assist users when they are about to fall (more significant chance of countering falls with cardiac tests that are being performed constantly).

Stryker

Stryker is a company that focuses on medical and surgical equipment, orthopedics, and neurotechnology. Stryker's orthopedic technology is of particular interest to us, as we are trying to develop an AI-connected device that prevents falling—an action often caused due to orthopedic problems (or connects to the feet). When investigating the various technologies that Stryker has developed, iBed Wireless is one of the devices that appeared.

iBed Wireless includes technological parts that we could potentially include and adapt to employ in the final AI-assisted mobility device. There are several pieces of technology that can be adapted for our device, including "a caregiver-centric fall prevention dashboard that provides caregivers with increased visibility to safe bed configuration compliance, fall protocols, and bed activity." These pieces of technology bring us the type of computing and software that is necessary to alert the user when they are beginning to fall or about to fall. Additionally, the sensors would allow for quick messages to be sent to the overall device, giving the medical device something similar to the human body's nerves. iBed Wireless, additionally, "helps enable wireless bed alarms, advanced fall prevention, electronic health records (EHR) and related documentation, as well as smart equipment management." The primary parts that we would be looking to extricate would be the electronic health records and the related documentation. Every senior citizen has their individual necessities and allowing the user to input their health records will allow the device to conform to each of the individual's needs. Advanced fall prevention is essential to the device we are trying to build, as well. However, as the term "advanced fall prevention" is not incredibly specific, utilizing the sensors discussed previously is the superior option.

iBed has all of the technology and sensors that we would need for a mobility-assisting device. To improve the technology that already exists, we would initially need to convert the technology present in a device that has the patient resting (or immobile) into a device that allows the user to be mobile. Our sole purpose is to assist senior citizens with their daily lives and the multitude of tasks that it constitutes, which leads to the conclusion that we are in need of a device that allows users to be mobile. Furthermore, the device must be flexible to fit the users' needs, as, perchance, the patients would require assistance with climbing stairs or moving across surfaces that are not completely horizontal (rough terrain, the floor littered with baby toys, etc). Our device would allow the user to easily navigate around any obstacle that presents itself in front of them and reduce the risk of falling.

AI or Smart Technology That Will Be Implemented Into The Machine

While adjusting the preexisting devices will greatly benefit those who utilize them, to create a device that will provide the most welfare for disabled people, it would be beneficial to incorporate AI or smart technology into the machine. There are many forms of smart technology or AI that already exist and are acceptable options to incorporate into preexisting devices as well. The different options for AI and smart technology to add to the tampered preexisting medical devices are shown below.

AI-Powered Wearable

Stanford Human Center for Artificial Intelligence recently came to the idea of having a wearable that an elderly person or someone who suffers from falls often could wear that would prevent them from falling. Their basic design for the machine would be involving "detection-and-activation systems" that would allow the group of

people who originally struggled with mobility to take part in common daily activities. Their technology is in the period of time where it is being tested for any potential errors and to find the ways in which the human body most commonly falls. This is done through using an AI-based "intelligent agent," who is tested in daily living conditions to find what the most common human response to certain types of falls is and what can be done to prevent such falls. The very device that is being perfected is an "exoskeletal device" that would provide "extra control and power" to the muscles near the hip area of the user. Through testing and tracking certain control values—such as the "user's acceleration and velocity of the center of mass" —if the system detects that the user is at risk of falling, it will add a certain "torque" to areas around the leg to alter the way the next step is taken.

While a system that could potentially be reduced or compacted into a simple wearable that does not add too much weight to the body is beneficial, there are several factors to consider with this wearable. The first being that there is no certain weight for the wearable in the first place, which could result in the wearable causing added pressure, leading to an imbalance in the way the body is held. This could lead to potential additional errors in the way the elderly person moves, reducing the value of the wearable in general. Additionally, the wearable will eventually have to be able to recognize exactly when the elderly person is actually falling in contrast to several other scenarios that occur on a day-to-day basis. As the wearable will be programmed to respond to certain scenarios in specific ways, and as each person's lifestyle is different, there is the potential of the wearable incorrectly predicting when the elderly person is falling. If the machine were to predict the person falling when the person was not in fact falling, the elderly person would have a bolt of torque applied near their legs, inevitably leading to the person falling anyways, or causing other serious medical side effects. Even in the reverse scenario, there could be serious problems; if the machine does not realize that the person is falling, the person would also end up falling and with no protection could injure themselves seriously. Furthermore, with the additional weight of the wearable, the person could end up crashing the device and releasing energy that could be potentially incredibly dangerous to the human body. Overall, in the several chance scenarios that the wearable does not sense falling correctly, there are several negative side effects that go along with these errors. As a result of these observations, it would be for the best of the elderly people's safety and in the best interest of the ideal artificial intelligence assisted mobility device, to not include the Stanford Human-Centered Artificial Intelligence department's idea for a wearable in the mobility device.

Media Pipe: Poor Body Posture Detection

MediaPipe is a machine learning platform where users can develop programs that involve artificial intelligence, Python, and many additional aspects of programming. In recent years, a group of computer scientists was able to develop an artificial intelligence/machine learning tool named the Body Posture Analyzer. This analyzer is able to detect the different joints and key points that flex and change the position of a human being. These points are analyzed by the technology and the technology then concludes the neck and torso inclination (or other parts of the body that are flexed) and whether it qualifies as "bad posture" or not. This poor body posture detection tool has the potential to assist users in perfecting their posture, or, with slight tweaking, can be repurposed to send a signal when the elderly person has reached a neck and torso inclination that makes them at risk for falling.
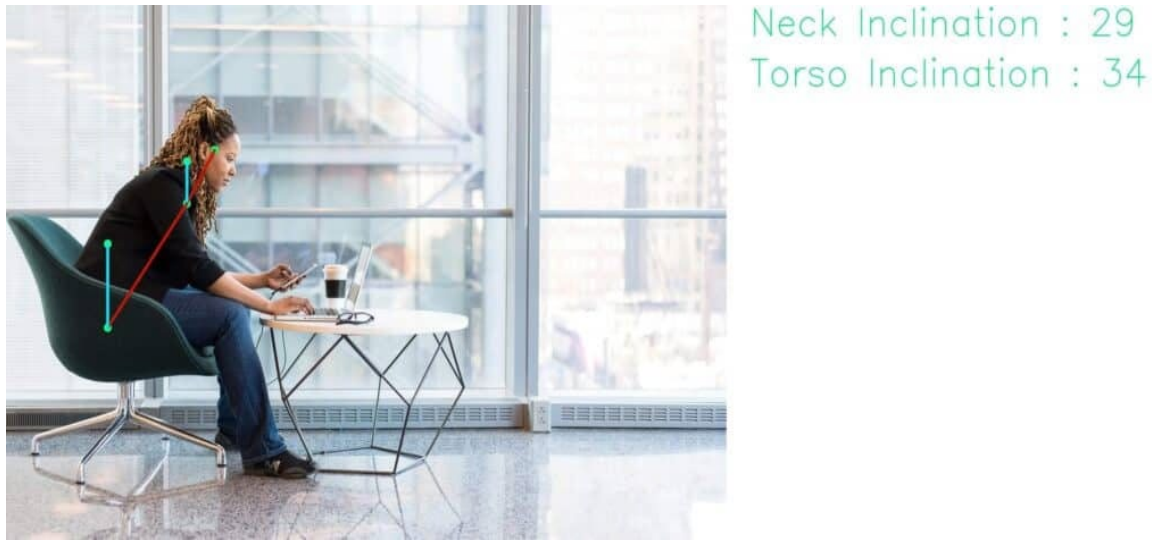
Figure 2. Machine Learning and Artificial Intelligence Technology Analyzing the Position of the Woman

The picture above shows how artificial intelligence calculates the woman's neck and torso inclination. While this woman may seem young, this technology would work just as well on an elderly person. In fact, as mentioned earlier, even a woman of this age can start to develop heart conditions that could lead to the eventual need for a mobility device. Elderly people could have their neck inclination and torso inclination measured similarly, however with sensors put in place that alert the elderly person or the person's caretaker when the neck and torso inclination is much higher. These values would have to be set higher due to the typical position that elderly people move in. Due to years of strain being put on their back and spine, most elderly citizens are likely to have a hunched back, meaning their natural neck inclination would be around 29 and their torso inclination 34.

The one downfall of the poor body detection device is that it may be difficult to incorporate into the actual mobility device, as it needs to be able to detect the person's posture by viewing the person. There is the alternative of having cameras set up with the artificial intelligence detector running and connecting that through sensors with the mobility device. However, seeing as that is a possibility that will require great costs and effort, it may not be the most manageable option for the elderly citizens. Overall, MediaPipe's poor body detection device would be a potentially good fit for the overall artificial intelligence assisted mobility device, but may not be the greatest match for the ultimate mobility device.
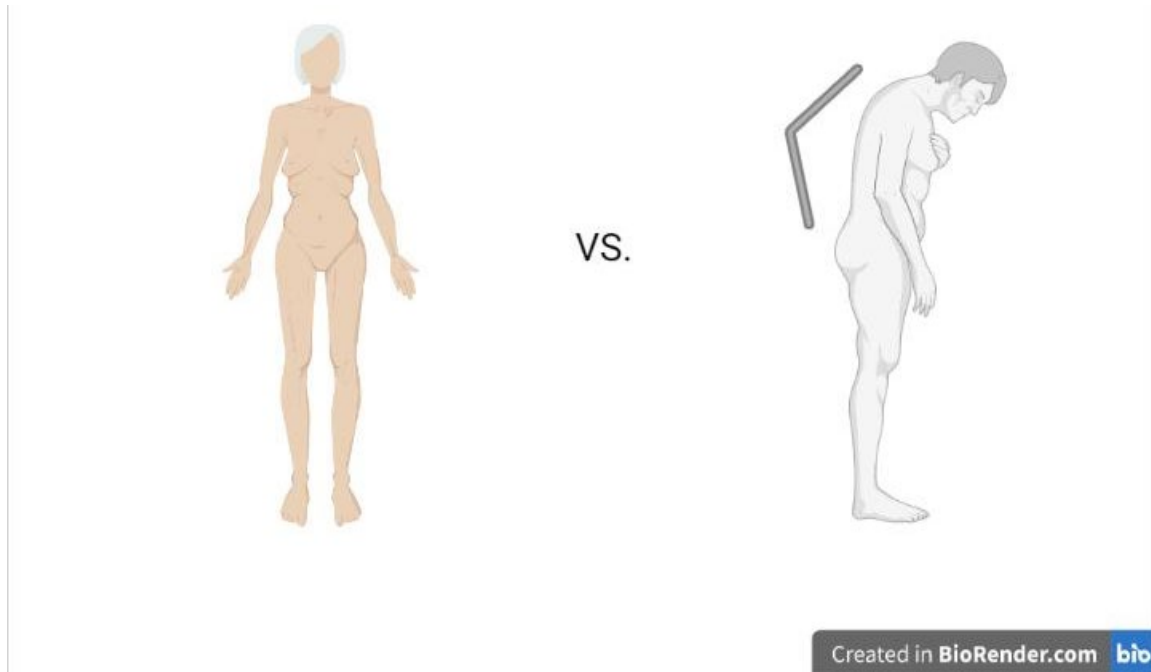
Figure 3. This image compares the natural state of an elderly person if they were able to stand straight to the natural hunched state of most elderly people.

Media Pipe: BlazePose

There has been the recent invention of another MediaPipe AI technology which is similar to the Media Pipe body posture detector. This artificial intelligence operated device, however, is more attuned to bodies that move. As such, the Media Pipe device created by Google called BlazePose is an even better fit for the overall artificial intelligence assisted mobility device that is the end goal. BlazePose is a very developed version of the original body posture detector, which can recognize sign language, give the user "full-body gesture control," and most important of all tracks the user as they move around. In comparison to the other artificial intelligence powered devices that track the body, BlazePose tracks far more "keypoints" on the human body, making it a stronger power device in power than the ones that employ "COCO topology." Since BlazePose is able to record the complete body's movements, it is far more suitable considering the ultimate goal is a mobility device that is flexible and well-suited to move along with the user. As a whole, Media Pipe's BlazePose artificial intelligence created by Google is one of the best artificial intelligence tools to be included in the ultimate artificial intelligence assisted mobility device.
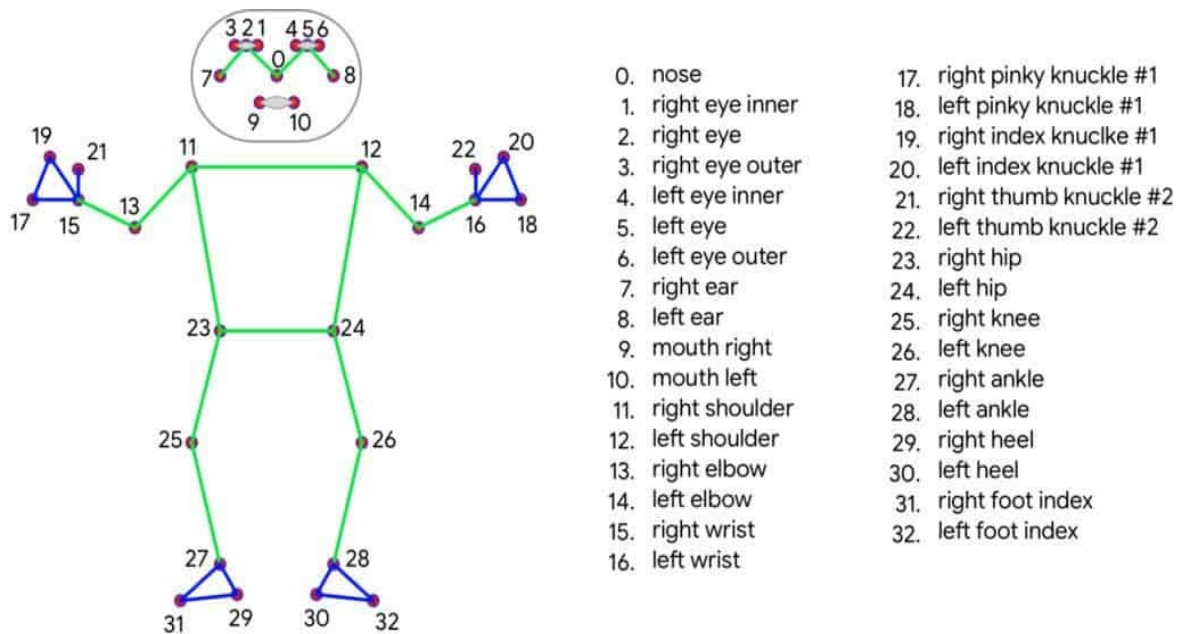
Figure 4. Description of Different Key Points on the Human Body That Flex

Conclusion

Connecting all of the different potential parts of the machine together, it was clear through the findings that a combination of using some of Stryker's orthopedic and fall-preventing technology with the Media Pipe BlazePose artificial intelligence could provide the potential ideal artificial intelligence assisted mobility device. It would assist people who have severe heart conditions that affect their mobility, provide flexibility for people who suffer from orthopedic problems that affect their balance, and in general, people who have trouble moving around due to old age. The medical technology company Stryker would be the best fit for this project in general, as it has the technological equipment that would be needed, such as sensors that are designed to prevent falls. Danaher has potential as a company that is in the top 10 of all medical technology companies, but seeing as Stryker specifically has orthopedic-focused equipment and sensors that could be utilized in the ultimate mobility device, it was concluded that Stryker would be the most suitable company to work with in order to get the quality and structure that is necessary for this product. When looking at the different artificial intelligence technology out there that specifically can track movement or can track the body in comparison to smart technology or smart mobility devices, the one piece of artificial intelligence that stands out is Google's Media Pipe BlazePose technology. While the other smart technology could certainly create a substantial and somewhat ideal machine considering the needs of the machine, it would not be as perfected without what Google's BlazePose technology and what it can offer. BlazePose will track several movements of the user and combined with the sensors that Stryker has created for fall prevention, certain movements can be coordinated to trigger those sensors, giving a warning to the user before they fall as well as their caretaker or whoever lives with them. This alert system would create a strong system to prevent several elderly citizens from falling, but additionally, provide a strong method of collecting and tracking an elderly citizen's history of falls, which could then be taken to a medical professional. With the alert system in place and the technology tracking the body, the doctor could more accurately diagnose the patient with any syndrome or physical disability that is causing their falls (or find a pattern amongst the different falls the elderly person has had), and thus, better recommend any course of action that should be taken to prevent the falls in the future.

When this machine was set out to be made, its intentions were not to completely eliminate the risk of falling again or to prevent whoever has the device from falling anytime they do. While the mobility device would try to prevent any senior citizens from falling as often as it can, the real problem can be tackled only if the elderly person chooses to report their history of falls and any other conditions to the doctor. Senior citizens have been known to be adamant about not needing to see a medical professional any time a problem come up with their health, as they believe that they are still young or that whatever incident occurred will not affect their health greatly. However, this is absolutely not the case. Before any mobility device comes into play, it is first and foremost necessary for senior citizens to understand that falls can be a serious detriment to their health. Falls can further increase any preexisting conditions they had or bring up new cases of syndromes or physical disabilities. To resolve these problems, it is necessary for us to talk to our communities and any elderly citizens we personally know about the importance of checking themselves with a doctor regularly, emphasizing the importance of telling the doctor about any falls they have had recently. The doctors can not diagnose accurately without knowing the history of all the medical disasters that have occurred. Reminding senior citizens about the importance of this will help their health overall.

All in all, the optimal medical device will require a combination of a flexible mobility device with sensors and the incorporation of BlazePose technology. However, ultimately, this technology will be worthless if the patient chooses not to tell the doctor their medical history of falls. As such, determined by all the previous research, it is necessary for the elderly citizens to let their doctor know about their history of falls and then start to use the ideal mobility device in order to track and prevent any falls.

Acknowledgments

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