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ECS 3390, 8:30 p.m.

9 March 2016

**Sensor Equipped Prosthetic Leg**

**Introduction**

People are injured every day, whether they are in an accident or in combat to protect their country. Injuries such as scrapes and bruises are easy to treat and recover from, but more serious injuries, such as amputated limbs, pose a more difficult recovery process. People without deformities or healthy limbs can sympathize with amputees, but they cannot truly understand the difficulties that the amputees must undergo. Thus, amputees are often forced to alter their relationship with people to adjust for physical limitations. A prosthetic limb with sensors in the bottom is currently in the works to give people feeling back. The multi-sensor prosthetic device can help amputees normalize their relationships with others by allowing them to regain their independence. At the same time, patients who receive prosthetic limbs will also experience side effects such as ghost pain, , functionality issues, and some reliance on others.

**Body**

Losing a limb, no matter how hard a person tries, will inevitably affect one’s life in many negative ways. The difference between losing a limb in the twentieth century and now is small, but the things that can be done to replace a lost limb have come a long way. Common tasks may require much more effort, and as a result, amputees will face difficulty finding and maintaining employment. In terms of social interactions, amputees may experience exclusion from friends or family members who cannot cope with the physical change. Besides the functional loss of the limb, the brain also undergoes serious cognitive changes. When a limb is lost, the area of the brain which previously had smaller and weaker connections will grow stronger because the brain overcompensates for the lost limb. Some people may experience a tingling sensation in the missing limb area when touching another part of their body. Some people, like Miles O’Brien feel the limb there even when it is gone. Miles says, “In my mind’s eye. I can feel every digit.”(O’Brien). Miles is talking about the ability to still feel his missing limb. The more the missing limb is related to sensation, the greater the change in the respective portion of the brain. This also means that large changes to the affected cerebral area will result in greater ghost pain (Hays).

Losing a limb can be more debilitating to life depending on the person’s stage in life. Childhood is the easiest stage at which to mentally and physically cope with the loss. The reason for this is that a child’s brain can adapt to physiological changes much better than can an adult’s brain. Thus, children are unlikely to experience ghost pain, and their perceived sensation of the missing limb will likely go away entirely (Primary source Dr. Hays). Any age between childhood and retirement involves greater mental and physical hardships. After retirement, it will be slightly less difficult mentally and physically. Adults will inevitably experience a loss of independence that will require extreme readjustment to their lives, in contrast to children who are dependent to begin with and are already constantly adjusting their lives. Those that are retired or near the end of their lives, like children, are already dependent on others for care and in the process of readjusting their lifestyle.

Leprosy will change a person’s life similarly to that of losing a limb. People with Leprosy weren’t allowed to vote till 1946, and were the center of constant discrimination (Leprosy History). The disease is curable but being diagnosed is the same as losing a limb until cured. Nobody wants to have missing limbs or leprosy. Both can be fixed but the memory of that time will remain in the mind of those affected.

**Device**

Acquiring the multi-sensor prosthetic device is more difficult to compared to that of a standard prosthetic device/leg. For example, before attaching a prosthetic leg to a patient, the patient must undergo surgery to move the nerve endings in their stump to the surface of the skin (Walsh). According to Professor Hubert Egger, the inventor of the multi-sensor prosthetic device, the procedure involves minimal risk and recovery time is quick (Magaldi). Surgery can seem daunting, but with low risk procedures, people might be more willing to undergo with the surgery. Since the recovery time for the surgery is fairly short, patients do not have to endure additional pain while waiting to be fitted with the device. Although the thought of having to undergo surgery may discourage some amputees from considering the device, the potential benefits outweigh the necessary inconvenience.

Widespread, mainstream use of a product requires cost-efficient and timely manufacturing of the prosthetic device. Design elements of the prosthetic device are reasonably straightforward, and therefore, the device can be easily duplicated. According to Walsh, the artificial leg is designed to have six sensors at the base of the foot, and with stimulators “inside the shaft where [the prosthetic] touch[es] the base of the stump”. Walsh also explains that the sensors on the sole of the artificial foot “measure the pressure of heel, toe and foot movement” as the amputee walks. The information from the sensors is then transmitted to the stimulators inside the shaft, which then vibrate to trigger nerves in the stump (Walsh). According to Egger, these nerves then send signals to the patient’s brain, giving the patient the sensation that his artificial foot “rolls off the ground when he walks” (Woollaston).

Since the device is composed of widely available technology such as sensors and the prosthetic cast, manufacturers can choose from a variety of options with regard to these components. Compiling these materials into one functional device will require great care, but the layout of the prosthetic device is not overly complicated. Therefore, the prosthetic leg is likely to be a product of mass production. In the future, improvements could be made by adding more sensors to the base of the artificial foot to allow for more accurate information to be transmitted to the stump nerves.

**Importance**

Amputees with prosthetic devices will benefit from a more advanced prosthetic device equipped with sensors. Many people lose limbs due to accidents, warfare, and disease. They need a way to re-enter their normal life, and prosthetics help amputees do just that. Many daily activities such as walking or tying shoes, depending on which limb is lost, can be very difficult even with normal prosthetics. Thus, the need for advanced prosthetics with sensors arises. Some leg amputees have to look at the ground to make sure they are walking properly and avoiding hazardous surfaces. A prosthetic device with sensors capable of relaying signals to the body will greatly alleviate the issue of having to focus on the ground rather than the environment. The proposed prosthetic device will also eliminate negative side effects of lost limbs such as ghost pains and impaired movement.

**Impact**

Prosthetics serve their purpose by enabling amputees to regain some functionality, but a more advanced prosthetic device can help reduce the issues not met by the previous device. In a survey of “...298 Vietnam war veterans and 283 service members/veterans from Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) who sustained major traumatic limb loss…”, 70.7% and 85.5% reported health status of excellent, very good, or good(JRRD). Prosthetics played a major part in the good health of the participants. Imagine if the veterans had more advanced prosthetic devices with sensors that helped them experience their environment more naturally. Life would be much more enjoyable, and coping would be easier.

One example of a man who benefitted from the advanced prosthetic device is Wolfgang Rangger. Wolfgang Rangger is the first person to try such prosthetic devices. He reports that the multi-sensor prosthetic leg allows him to feel like he has regained his foot (Magaldi). According to Magaldi’s article *New Prosthetic Leg Helps Patients Regain Feeling Post-Amputation, And Fights Phantom Limb Pain*, Rangger suffered from ghost pains after his leg amputation and relied on daily medication to subdue the pain until he began using the multi-sensor prosthetic leg. The article states that Professor Egger hopes that this decrease in ghost pain will be experienced by all users of these multi-sensor prosthetic devices. The decrease in the amount of ghost pain experienced is caused by the brain finally receiving signals from the missing limb area (Woollaston).

No longer having to bear the constant pain caused by amputation is a huge relief for an amputated individual. Thus, amputees with multi-sensor prosthetic limbs can enjoy everyday activities without the burden of pain. Resting comes much easier, and as a result, amputees can lead healthier lives. Reliance on pain medication is also reduced, which eases any medical side effects amputees might experience. Rangger states that with the prosthetic limb, he is able to determine the surface he walks on, which, and along with the decrease in ghost pain, it makes him feel like he has gained a new outlook on life (Cuthbertson). Based on Rangger’s experiences, suggest that significant improvements can be made to an amputee’s daily life with a multi-sensor prosthetic device. Such positive results produced by the device demonstrate the importance of having this prosthetic device available to the public.

**Development**

Development of the new prosthetic limb may involve issues of availability as well as cost. Professor Egger is hopeful that companies will want to produce this prosthetic so that the artificial limb can be more affordable (Magaldi). The current cost of the prosthetic ranges from $11,000 to $30,000 (Cuthbertson).A lower extremity prosthesis leg can range in cost from $5,000.00 to $50,000 (Disabled World). Affording the prosthetic device could be a challenge for many individuals. The development and manufacturing costs of such a helpful device will always be of concern, so more research will be needed to improve the manufacturing efficiency of the product. Without sufficient investment and financial support, the life-changing prosthetic may never reach people those who need it the most.

**Conclusion**

The prosthetic leg outfitted with sensors and stimulators is a realistic alternative to the conventional artificial limb. The cost to purchase and install a prosthetic limb is manageable for most prosthetic limbs, but advanced prosthetics that have fully functioning sensors come at a much higher price. The costs for the multi-sensor prosthetic leg will hopefully decrease as the device is further researched and produced. People all over the world will benefit from the production of the device. Even those who still retain their limbs but are in danger of losing it due to damage or the promise of future damage. There are no reasons even cost that someone should be against the device unless they don’t believe in medicine. The proposed prosthetic device will change every aspect of the amputee’s life for the better, and is a technology everyone should support.

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