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DESIGN AND CONTROL OF A PROSTHETIC KNEE FOR TRANSFEMORAL AMPUTATION

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Abstract: In this study, transfemoral amputations and prosthetic knees evolved for transfemoral amputations are investigated and the electronic control unit of prosthetic knees is designed. The first stages of this work contain information about human walking in medical meaning and bipedal walking. Then, definition of transfemoral amputations, leg biomechanics when walking and phases of walking is discussed. Then the importance of creativity for designing human body is mentioned. After that, prosthetic knee design for transfemoral amputations is mentioned and prosthetic knees developed by worldwide companies are investigated and discussed in details. At the last stage, electronic control unit is designed and produced for prosthesis used by above knee amputees'.

Keywords: *Transfemoral Amputation, Prosthetic Knee, Bipedal Walking, Electronic Control of Prosthetic Knee*

1. Introduction

Human beings possibly have the most complex structure on this planet. This human body structure is single but comes into existence of billions of smaller structures of four major kinds. Unfortunately, some parts of this structure sometimes could not function properly because of diseases, accidents such as an amputation. In this study, limb amputation, one of the body amputations, will be discussed in details.

The reason why lower knee prosthesis is investigated in this study is that walking is one of the most important and composite process of human body. The knee is the significant role at human walking especially stability of walking, and so worth of knee prosthesis for the above knee amputation is understandable.

The design of human body is very important in engineering creativity. Because human is assamblies of very complex subsystems and mechanisms. Despite a very high level of technology and science is still not completely solved the structure of human body in engineering.

2. Comparison of marketed prosthetic knees

In order to control the throttle valve of pneumatic cylinder it's used apparatus at the previous prosthetic knee. In recent years, with occurrence of intelligent knee we can use remote control easy to program for all types of motion.

Table 1. Comparison table of prosthetic knees

PRODUCT	WEIGHT	MAX FLEXION	CLASSIFICATION	STANCE PHASE	SWING PHASE
Nabtesco Intelligent knee	1015 g	160°	Wt limit 100 kg	Four Bar linkage mechanism	Microprocessor control Pneumatic
Nabtesco Hybrid knee	1290 g	140°	Wt limit 100 kg	Hydraulic and MRS	Microprocessor control Pneumatic
Endolite IP+	1247 g	135°-140°	Wt limit 125 kg	Mechanical weight activated stance control	Microprocessor control Pneumatic
Endolite Smart Adaptive	1361 g	140°	Wt limit 125 kg	Microprocessor control Hydraulic	Microprocessor control Pneumatic
Otto Bock C-leg	~1300 g	125°	Wt limit 125 kg	Microprocessor control Hydraulic	Microprocessor control Pneumatic
Ossur Rheo knee	1630 g	120°	Wt limit 100 kg	Microprocessor control Hydraulic	Microprocessor control Pneumatic
Ossur Mauch knee	1140 g	115°	Wt limit 136 kg	Single axis stance control	Single axis swing control

3. Remote control design of prosthetic knee

The most important section of designing intelligent knee is control unit of knee. All phases of walking is decided in the control system. Most of these types of prosthesis are collected and then disposed by their manufacturers so that there are no samples to examine for designing new one. That's why creativity is important for this study.

In order to control the throttle valve of pneumatic cylinder it's used apparatus at the previous prosthetic knee. In recent years, with occurrence of intelligent knee we can use remote control easy to program for all types of motion.

The programming procedure is simply to select a speed of walking, and then adjust the valve position of the swing phase control by pressing an increase / decrease button. The settings are then saved at the required speed. Repeating this sequence at two other speeds, automatically leads to the generation of valve settings.

Firstly, an audible sound confirms receipt of signal and end of task at remote control. The flashing led's switch to selection of speed, inviting the user to select one of speeds or reset. After selection of a speed, the amputee is asked to walk at that speed at right distance while the prosthetist can observe the gait. The increase (+) or decrease (-) of resistance to flexion controls how fast or slow the limb should be extending. An audible sound confirms each resistance change with the additional feature.

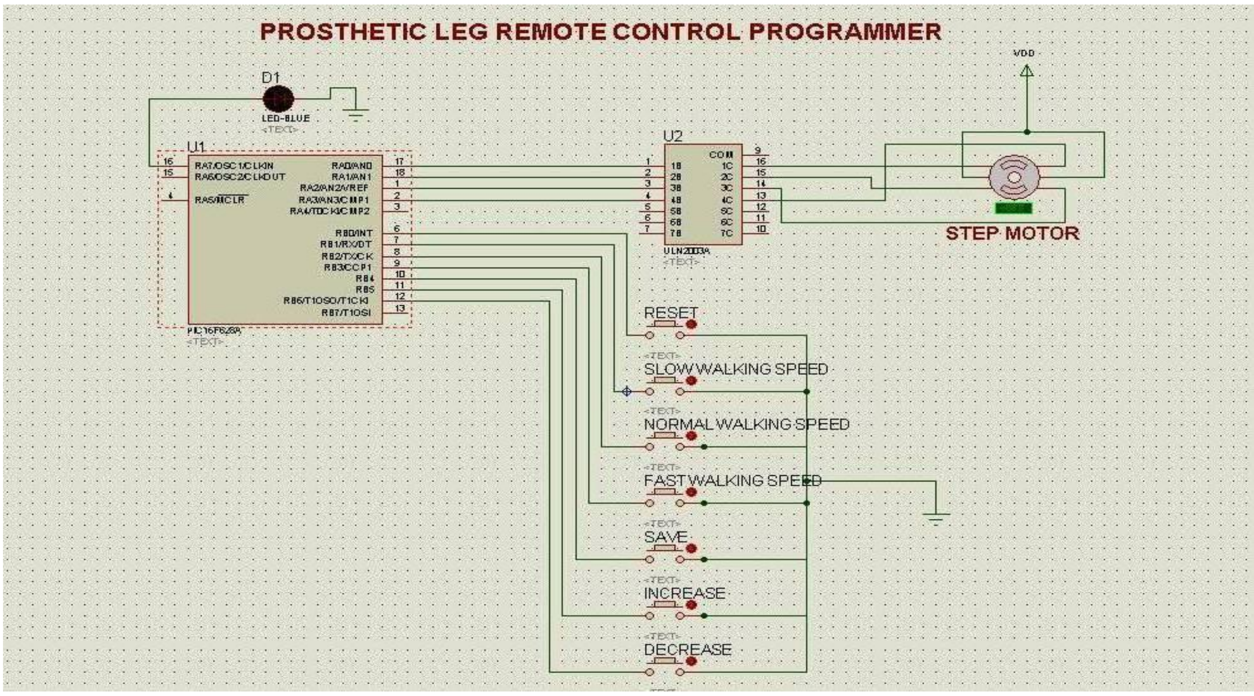

Figure 1. Electronic circuit drawing by Proteus

Once satisfied with the swing phase performance on any step, the SAVE button is pressed. This stores the selected valve settings as well as the average speed at the time of pressing the key. The sequence is repeated for another two speed selections and this will complete the programming procedure.

It is useful to note that the system goes to automatic mode whenever the SAVE button is pressed. This means that the valve position automatically changed with speed. It is possible to go back to the program and simply adjust the valve setting at one speed or change the walking speed selection at a particular valve setting.

The values stored in permanent memory can only be over written by a new programming sequence.

4. Discussion and conclusions

The purpose of this thesis is to investigate prosthetic legs developed for transfemoral amputations to walk healthy again, and to give information about parts of prosthetic legs, and also to design control of phases of prosthetic knee with microprocessor.

The importance of design creativity is mentioned above. This type of studies should be supported more.

From study results, designing and manufacturing prosthetic legs for above knee amputees are the following points should be taken into consideration.

Prosthetic legs should be designed light as possible. Therefore, the material selection part is very important during the design of prosthetic leg. Composite material should be preferred as a material of knee frame because the greatest advantage of composite materials is strength and stiffness combined with lightness. Titanium also should be preferred as a material of other components such as knee joints instead of steel or aluminum as possible as because of same reason like using composite material.

Prosthetic legs should appeal to a wide range of amputee patients, so prosthetic legs' size has large spectrums for long or short patients because leg length is direct proportional with human length. Moreover, the carrying capacity will be used in the prosthetic leg in a similar way to apply to the seriously heavy weight patient should be because today, most of prosthetic leg has 100 kg carrying limit.

The stability of designed prosthetic leg is very important. For this purpose, the harmony of knee joint and the control unit should be synchronized.

The longevity of the production of leg prostheses is very important that is to say Durability. This is explained in the first clause is related to material selection.

The produced prosthesis leg should be energy saving. Easy rechargeable and designed long life batteries should be used.

If the prosthetic leg is used exclusive use of the special places, such as athletes amputees, it should be changed certain structures based on the conditions. This type of real patients by taking into account the above items that are most optimally designed legs.

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