**Mohsin Mehmood, Hafeez Shittu**

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**Intelligent Prosthesis**

**Introduction:**

Complexity runs rampant in each mechatronic system, which includes closely related mechanical parts, circuitry, and computation, especially when used with a mobile robot such as a human body, inspiring the growth of the intelligent systems field.

Following shows the lower limb prosthetic design based on mechatronics. After that, we analyze the aforesaid approach.

**Bio-mechatronics and biological systems:**

Nature inspires technique. Recent scientific discoveries have help flourished the field of bionics.

Examples of bio-mechatronics include prosthetic limbs, artificial eyes, and hearing devices. A complete understanding of human body is necessary. This object is made up of trillions of cells, divided into many systems each capable of carrying out specific functions. For instance nervous system analyzes the input sends the output of contraction to the right muscle sets to allow motion. A brain contains billions of neurons that act as simple processors, whereas the rest of the body contains countless sensors and actuators. A direct study allows the dawn of new robotics era.

**Prosthetics:**

It is the study of combining artificial objects to mimic body parts, such as lower limbs, to allow an amputee to carry out basic functions. Different parts include foot-ankle assembly, shank, socket, knee, and suspension devices. Knee types include single axis, polycentric, hydraulic etc.

**Human locomotion:**

Lower limbs allow locomotion through walking or running. In biomechatronic speak, it includes input, processing, actuation and feedback. Walking cycle is primarily reduced to stance (surface contact) and swing (mid-air motion) variables or a trilogy of IC, LR, MSt, TSt, PSw, ISw, MSw, and TSw (I, M and T stand for initial, middle and terminal, St and Sw for stance and swing, and C and R for contact and response).

Walking, the most energy efficient translation, has components including pelvic rotation and tilt, knee flexion and motion, foot and ankle motion, lateral pelvic displacement, kinematics, kinetics, ground reaction and muscle activities. Kinematics such as linear and angular displacements, velocities and accelerations of various body parts are studied through available systems. Kinetics are studied in a similar whereas EMG, non-invasive and invasive, proves valuable for muscle activity measurement.

Abnormal locomotion, when compared to normal motion, helps diagnose gait problems in the amputees.

**Current Prosthetics:**

Structured as well as functional materials that weigh less and are strong. Most compatible metal for core parts is titanium. Polypropylene and polyethylene are preferred structurally and functionally respectively. Copolymers can adopt with the growing limb. Carbon fiber composite is at the heart of current research. These are lighter, stronger, cheaper, more flexible, comfortable and corrosion resistant.

Modern prosthetics have components that mimic the core systems. Skin-like composite of silicon, PVC and urethane make prosthetic exteriors flexible, stain and heat resistant etc., without native rejection. Lifelike 3D replicas have also been produced.

**Sensors:**

Self-sensing (subconscious) and mechanoreception apparatuses are necessary for locomotion. In prosthetic devices, sensors work, such as accelerometers and gyroscopes, with on-board microprocessors (akin to CNS) to apply algorithms and allow terrain particular motion. Actuators include magnetorheological and series elastic kinds, the former requiring particles in a fluid changing viscosity by applied magnetic fields while the latter includes motor, gears, resistor and load in a series circuit.

**Intelligent control, transfemoral and transtibial prostheses:**

Humans adapt to terrains. It requires continuous processing of changing input. Advanced microprocessors are capable of the right speed needed for adaptation, allowing amputees a variety of functions. For AKA, a combination of knee and ankle-foot components is needed, compounding the problem. Examples of above and below knee prostheses include smart adaptive knee and Epirus.

**System design and development:**

Design for lower limb prosthetics includes normal locomotion, interaction with the user, comfort, adaptation to different terrains and environments, and energy efficiency.

**Specific Requirements:**

These include stance phase support for varying yields to suit different amputees, variable resistance adaptable to walking speed, user specific knees, stumble control for varying levels of safety, allowance of different walking speeds, and allow wearing of different retail products.

**System development**

Many changes have been made to allow foot dorsiflexion, knee flexion and rotation, and greater intelligence. Less and more intelligent classification allow us to better study adaptive prostheses. Benefits include knee point damping, stumble detection, natural gait allowance, shock absorption, and ability to walk up and down stairs.

**Transfemoral prosthesis:**

IP+, an ideal example, is capable of more degrees of motion working with the optimization of hip power availability. It also allow stair travel and stumble resistance. Schematics have been created based on the feedback from various end users.

Another example, called magnetorheological knee prosthesis has following requirements; understanding of motion, identifying components and algorithms, and testing and feedback. The developed system contains actuator, two force sensors, circuitry and battery. Rotatory potentiometer measures position, and eventually velocity and knee torque. Walking is divided in five phases to develop algorithms. Finally, a clinical evaluation is carried out to match an amputee’s requirements.

**Transtibial prostheses:**

Transtibial prostheses incorporate human ankle foot behavior although passive prostheses are unable to create positive work. Active prostheses requires design, model, testing and verification of the system, design of the control system, trials and necessary adjustments and finally and system verification performance.

**System specifications:**

Prosthesis should consider amputated counterpart’s weight, execute necessary power and rotation, adjust stiffness similar to human ankle, properly control joints and absorb shock during heal strike. Mechanical elements include socket adaptor, high power output motor, series elastic actuator module, ball screw, series spring, unidirectional parallel spring, and carbon composite foot. Various control approaches include biomimetic and neural network EMG controllers as well as hierarchical control with intent recognition.

**Future prosthetics:**

Smarter prosthetics should require a deeper understanding of locomotion, advances in the nervous system and prosthetic device interface, and cutting edge soft sensor development.

**Conclusions:**

We mentioned and summarized intelligent prosthetics. To create a smart prosthetic, we should study human locomotion. Modern prosthetics available to the amputee are passive generally but more intelligent designs with active components have provided competition. Better sensors, machine intelligence and actuators show great promise. Research and development examples are also presented above. Future will ask for a new generation of active devices. Artificial muscle actuators and direct nervous system-prosthetic devices are included in the research section.