Title: "HYDRAULIMB" --- BATTERY-FREE MICRO HYDRAULIC POWERED & THERMAL-SENSITIVE ARTIFICIAL HAND FOR AMPUTEES

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At present, only myoelectric hand have features of grip patterns selection and rotational wrist. The primary disadvantages are their heavy weight, cost and unreliability of control. It contains a battery and motors inside. Therefore, it consumes lot of electricity and needs regular maintenance. Based on the above reasons, traditional prosthetic hand is still widely used.

Not only does "HYDRAULIMB" have advantages of traditional prosthetic hand, such as highly practical, battery-free and low cost, but also has the advantages of myoelectric hand. For instance, it has selectable grip patterns and a rotational wrist. It also contains some innovative features that cannot be found in any products else, for example thermal-sensitivity fingertip and single-handed operational grip button. The precise grip provides the most accurate hold for picking up small items easily like coins and small nuts. The thermal sensitivity features mean users can 'feel the heat' when touching heat objects. If the temperature of object is higher than 32°C, the color of "HYDRAULIMB" will change from black to red in order to caution users to pay attention. The main part of our product is made of carbon fiber. Its weight is 53% and 66% less than traditional prosthetic hand and myoelectric hand respectively. Though the cost is only USD150, its performance can be compared with high-priced myoelectric hand.

Project Title: Generating Gray Code by Double Chinese Ring Algorithm

A Gray Code sequence is a set of 2^n binary numbers in which only one bit changes between two consecutive elements and this property helps in reducing errors in data transmission in hardware. A few methods are available to generate Gray Code, like XOR which must first include the conversion of binary numbers or the use of mirroring method which is only efficient for generating the whole set of sequence. This project introduces a new algorithm in which conversion can be directly changed from a decimal number to Gray Code. It does not involve calculating the previous sequence or require and no recursive function.

The new algorithm generates Gray Code in a more effective way by using the idea of Chinese Ring - 'Double Chinese Ring Algorithm'.

The double Chinese Ring algorithm can be viewed as two parts, the first part being a solution of n^{th} rings Chinese Ring, the second part is the reversed solution of $(n-1)^{th}$ rings Chinese Ring. There are four unique formulae created and the algorithm further fits into the Gros Sequence to ensure correctness and completeness.

By writing computer programs for existing methods, the running time of the new algorithm is faster than the conventional method. Hence, our new algorithm is more effective than the conventional one.

Project Title: Super glue for tree defects— investigation and characterization of 4-in-1 material for the treatment of tree defects

Typhoon Mangkhut left a trail of destruction of trees. Branches of stricken trees were chopped, and now those cross sections are mostly infected by fungi. Invasion of fungi and myriad of other factors would also cause detects which weaken the health of trees, they may fall and pose a risk of public safety. Nowadays, treatments are mostly addressing single problem or invasive, for example spraying drug targets the fungi but it cannot provide physical protection of the defects. Painting prevents the infection of fungi, but it cannot offer support to weakened branches, while reinforcing strength of branches using metal plates but it cannot cure tree infection neither.

Addressing the incomprehensive treatments, we are investigating the possibility to modify the biocompatible poly(vinyl) alcohol (PVA) using metal salt $CaCl_2$ as treatment materials (super glue), and cover it with carbon fiber cloth to support the tree defect.

Results showed that, PVA modified with 10% $CaCl_2$ showed comparable adhesive strength as commonly used wood adhesive, Soy Protein Isolate (SPI). It offered stable release of drug, copper (II) sulphate (8.8mg/ml), which meets the standard dosage in farming. Modified PVA also retained 60% of water, which may offer sustainable release of drugs continuously. We also found a clear zone, when treated with the super glue, in an agar plate cultured with bacteria showing its anti-bacteria property. Furthermore, treated defect-branches showed significant higher flexural modulus in three-point bending tests than the non-treated ones. At last, we successfully applied it on a defect created in Osmanthus fragrans, first pasted with the PVA super glue, and then covered with carbon fiber cloth for strengthening. The whole process did not require complicated tools nor long treatment time, and PVA showed better adhesion than SPI.

In conclusion, PVA super glue provides a 4-in-1 treatment, including physical protection, wound defects filling, stable and long-term drugs release, and it further reinforces the strength of weakened tree branches or stems.

Project Title: Flexible and Wearable Direct Urea Fuel Cell

There is currently an interest in developing wearable energy harvesting devices as the booming of various microsystem applications, such as health care, medical rehabilitation, athletic training, and outdoor equipment. Conventionally, wearable devices are mainly powered by batteries and thus have a limited working time period. Energy renewal or battery recharge for the devices is unavoidable. To address this issue, the self-powered scheme, in which the device's power is supplied by an attached wearable energy harvester, is increasingly attracting attention.

Our wearable energy harvesting device, direct urea fuel cell (DUFC), aims at generating electricity by using urea in sweat. An Cu-Zn-Ni alloy-based orderly aligned nanorod array anode is integrated with a CQD-Carbon electrode and assembled on a flexible textile substrate. $Cu(OH)_2$ aligned nanorods were firstly grown on the Cu-foam by immersing Cu-foam in alkaline $K_2S_2O_8$ solution, followed by chemical reduction to give Cu nanorod array. Cu nanorod array was then alloyed with Zn in alkaline $Zn(OH)_4^{2-}$ and doped with various percentage (0 – 20%) of Ni by hydrothermal treatment with $Ni(OH)_4^{2-}$ solution, followed by annealing. Nanostructured morphology, chemical composition and crystal phase were examined and confirmed by SEM and EDX mapping and XRD analysis.

Wearable DUFC prototypes were prepared to investigate the effects of temperature, pH environment, concentration of electrolyte, nanostructure, chemical composition and percentage of Ni doping on anode, type of cathode on its electrochemical performance. The electrochemical performances of DUFC were investigated to determine the power capacity and energy capacity of a unit cell under different conditions. Our best model exhibits an open circuit voltage of 0.72 V and a power density of nearly 12.1 mW cm^{-2} and energy capacity of 15 mWh when human sweat was used as fuel, air as oxidant at 298 K, which open up the possibility of developing the real-life application of a soft, flexible wearable direct urea fuel cell using human sweat as the biofuel.

Project Title: **Identification of Broad Spectrum Antimicrobial and Anti-Biofilm Effects of Novel Compound 1,2,3,4,6 Pentagalloyl Glucose on Pseudomonas Aeruginosa**

Pseudomonas aeruginosa is an opportunistic bacterium that causes serious infections in immunocompromised patients, such as those who have severe wounds or cystic fibrosis. Although many antibiotics are available for treatment of P. aeruginosa infections, adaptive resistance mechanisms in bacteria can cause antibiotic resistance and bacterial biofilm formation, and increase the persistence of the bacteria. In cystic fibrosis, biofilm complexes can thicken the already sticky mucoid secretions, which can result in chronic lung infections that increase the likelihood of life threatening complications.

Our research explored the antimicrobial and anti-biofilm effects of pentagalloyl glucose (PGG). Its antimicrobial properties were determined through culturing P. aeruginosa strains PAO1 and resistant strain PA14 in the presence of PGG, and recording the bacterial growth-curve through absorbance (OD) measurements for 10 hours. Its anti-biofilm properties were determined through culturing PA14 in the presence of PGG, and quantifying the biofilm cells through crystal-violet staining.

Our results showed that PGG inhibits 30.5% growth of PAO1, 38.7% growth of PA14 and causes 41.3% reduction of biofilm formation of PA14. PGG was shown to be a more effective inhibitor of PA14 growth and biofilm formation than the antibiotic Rifampicin, as well as current commercial anti-biofilm agents like nitrofurazone and silver hydrogel. Possible applications include combining PGG with existing antimicrobial treatments for resistant strains of P. aeruginosa, and coating medical devices that are susceptible to biofilm formation with PGG to reduce biofilm formation. This novel compound could greatly help reduce the susceptibility of immunocompromised patients to this highly-virulent bacteria.