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A Low-Cost Dynamic Light Scattering System for Detection of Viral Aggregates

Prepared by Lindsey A Barner and Alexander G Roth

Access to HIV diagnostics and viral load monitoring in developing nations with endemic HIV-1 infections, such as many sub-Saharan African countries is limited. Current methods are either high-cost diagnostics that quantify viral load, typically in central facilities, after weeks of processing, or else fast but non-quantitative methods unable to measure viral load. Because treatment must be adjusted depending on viral load, a low-cost diagnostic that can quantitatively identify how many viral copies a patient carries would improve treatment outcome. Partnered with the Macha Research Center in Zambia, Diagnostics for Viral Diseases aims to design such a diagnostic device by combining recombinant protein engineering with an optics-based particle-sizing technique, dynamic light scattering (DLS). We have explored designing a low-cost DLS apparatus and have assessed its capabilities and limitations. Among our innovations is the use of silicon photomultiplier detectors with custom signal processing circuitry and field-programmable gate array (FPGA) technology. This system could potentially serve as DVD's capability to size and thus diagnose viral aggregates.

Breath of Life: Pressure Swing Adsorption Oxygen Concentration for Hospitals in the Developing World

Prepared by Kristen Frawley, Caleb C Sisson, and Jordan T Sponsler

The Breath of Life project team has partnered with Macha Mission Hospital in Zambia to meet the need for medical oxygen at developing world hospitals situated in tropical climates. High humidity levels damage the zeolite particle beds in pressure swing absorption oxygen concentrators, which in turn causes premature failure of the devices. This drives up the cost of healthcare in these areas. In a developing world context, the lack of ready access to parts and maintenance means that the failure of oxygen concentrators can leave patients in respiratory distress without the oxygen they need to survive. Our team is designing a dehumidifier using electrostatic precipitation that is attachable to the air intake of oxygen concentrators to remove moisture from the ambient air before it enters the machine. Our current prototype uses a high voltage potential to charge and collect water particles out of the air. A long-term solution that is currently being developed is a hospital-wide oxygen system that is primarily driven by compressed air to create concentrated oxygen when the power is out. The system will use compression and rapid expansion to dry the ambient air before it enters modular oxygen concentrators and travels throughout the hospital.

Cunningham Club Foot

Prepared by Rebekah L Forshey, Vy T Ho, and Paul J Stoltzfus

The Cunningham Clubfoot project is focused on aiding children in Kijabe, Kenya that are born with clubfoot. If clubfoot is left uncorrected it can affect one's ability to walk on their own which can inhibit one's ability to be independent and provide for themselves and/or their family later in life. Our goal is to provide a more comfortable, convenient, and effective clubfoot brace than what is currently utilized. One of our partners, Mr. Jerald Cunningham, a board-certified prosthetist and orthotist, invented and developed the Cunningham Clubfoot Brace and currently manufactures them at Cunningham Prosthetic Care. Our Collaboratory team is in the process of replicating Cunningham's design so that it may be 3D printed and used in Kijabe, Kenya with the assistance of our other partner, CURE International. Our poster will focus on defining clubfoot, force and finite element analysis of the Cunningham Clubfoot Maintenance Brace, 3D printing results to date, cost analysis of alternative production options, and initial investigation into hygiene concerns with 3D printed products.

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Design of a Muscle-Activated Prosthetic Hand

Prepared by Alaric A Kobzowicz and Keith Wei Luen Lim

Due to the financial burden in purchasing a myoelectric prosthesis, which can cost upwards of $75,000, this project aims to design a low-cost alternative. Such devices are sought after because of their ability to closely mimic the anatomy and motion of the human hand through a combination of functionality, versatility, and natural appearance. This prosthesis is controlled via electrical signals generated by muscle contractions in the residual limb, which are read by a Myoware muscle sensor and accompanying electrodes. An A/D converter, Arduino, and motor driver then work in conjunction to interpret the intensity and pattern of the signal in order to output a certain set of commands to 3 motors, which accordingly move the prosthetic fingers to fixed grip patterns. Worm and spur gear couplings and pinned mechanical linkages achieve the latter. The current design designates one motor to the movement of the thumb, one to control both the first and second digits, and one to control both the third and fourth digits. To further alleviate costs, the structure of the prosthesis is to primarily be 3-D printed using available resources at Messiah College. This device is planned for a patient with a transradial (below the elbow) amputation and will be custom fitted and sized on a client-to-client basis. As a standard of measure, the overall cost is intended to remain below $1,000.

Viral Load Determination for HIV-1 for the Macha Research Hospital Using a Novel Recombinant Protein and Heparin-Affinity Protocol

Prepared by Lily I Gaudreau, Daniel G Haas, Danielle C Reimer, and Brianne N Roper

The HIV virus is endemic in sub-Saharan Africa with recent WHO reports estimating that over 88% of the world's HIV-positive children reside in the area. While viral load monitoring is essential for successful treatment, industry-standard nucleic acid assays are often costly or inaccessible to many regions. Consequently it is necessary to develop a cost-effective technique for measuring viral load. Our approach is to use a recombinant protein consisting of a fluorophore (GFP) and a HIV-binding domain (mD1.22) dimer that could be used to cause viral aggregation. The presence of aggregates can be detected using photon correlation spectroscopy, allowing for the direct quantification of HIV load. To explore aggregation dynamics, we have custom-written a Monte-Carlo simulation, allowing for the exploration in silico of the effects of virus and probe concentrations. To date, our results suggest that concentration of native virus concentrations will play a key role. As a result, we have opted to explore a method using immobilized heparin-agarose microspheres to capture the virus and remove it from the blood sample. We are currently exploring the possibility of detecting viral proteins directly on the agarose microspheres instead of in solution, obviating the need for ultracentrifugation.

Facilitating Organizational Networking (Henosis): Mobile & Web App Development

Prepared by Joshua L Conrady and Mark A Musselman

Through online tools, Henosis seeks to facilitate collaboration, foster community outreach and enhance member participation among charitable organizations and churches. Current developments will result in a release of our website for the second round of alpha testing in May 2017 and our mobile platform for alpha testing in May 2018. Mobile and web teams are currently working on API connections which map user functions to database values. In other words, we are working on connecting our mobile application to the web platform so that all of the functions of the website are available to a mobile user. Our main goal is to make the communication between churches and charitable organizations more efficient and transparent, to encourage new participation and outreach in target communities throughout the United States. We plan to have at least twelve churches in three states using our platform on release. Targetted marketing and client interfacing underway has produced interest in our product including churches actively testing it. Two key clients includeEastside Church of Christ in Colorado Springs, CO and Ashburn Presbyterian Church in Ashburn, VA.

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WERCware: Stress Detection Via EEG

Prepared by Derrick N Peterson and Josh D Thomas

The WERCware project team has been designinga system to provide wireless remote job coach services to peoplewith developmental and cognitive disabilities. For that purpose, we haveinvestigated electroencephalography (EEG) as a way to monitorhuman stress. Published studies have shown that by sensingelectrical activityin various parts of the brain, EEG canmonitor measurable changes in emotional state. For further experimentation, WERCware has acquired an Emotiv Insight (EI) wireless EEG headset. From the EIheadset, wehave collected and examined data in search of evidence for the human stress pattern. To facilitate this process, we have modifiedan existingartificial neural network (ANN) to classify EEG data as stressed or not stressed. The modified ANN is based on one previously builtby WERCware foraudio data, shown to detect human stress with a high rate of accuracy. Currently the EEG ANN code compiles; it creates a neural network, trains the network based on sample data, and processes data from the headset in real time. The EEG ANNhas been trained on simulated data;training it on real EEG data remains for future work.

Prosthetic Knee for Burkina Faso

Prepared by Kaleb E Burch, Vaughn W Chambers, Ashley Hah Chien Vern, and Marissa K Kuhns

In Mahadaga, Burkina Faso, the Centre for the Advancement of the Handicapped was once able to create full prosthetic legs. The Centre accepted prosthetic knees from a donor and made the rest of the leg with their own resources. However, they have exhausted the supply of donated knees and are no longer able to assist leg amputees. Our group aims to design a simpler prosthetic knee that can be manufactured in Mahadaga, and is compatible with the rest of the leg that the Centre has been using.Through this work, we hope to be better able to serve our client in the future and to share with them the Christian faith.

Sustainable Mobility: Taking an Assistive Mobility Technology from Prototype to Production

Prepared by Jakob Davenport, Joshua D Kunkle, and Morris K Taylor

The mission of the Sustainable Mobility Project is to equip our partner, the Centers for the Advancement of the Handicapped in Burkina Faso, West Africa, with an appropriate and sustainable method for locally building and distributing our mobility tricycle design to those in need. In rural West Africa, this personal mobility technology brings freedom and empowerment to some of the most marginalized persons in the world. Within the past year, we have shifted our focus to the development of tools and processes to facilitate scaling the manufacture of Collaboratory electric tricycles from single to multiple units. Ultimately, we aim to provide our partner with the ability to effectively meet the mobility needs in their community.

Specifically, this year the Sustainable Mobility Project has focused on the manufacturing development of the structural frame, the drive train assembly, the motor cast housing, and the electrical control system. In each of these areas, we evaluated former manufacturing techniques and improved these techniques to be more successful in future production of mobility tricycles in multiple international locations. In January 2017, for the first time ever, the team built five electric tricycles with our Burkinabé partners in Fada, Burkina Faso. Moving forward, the team willfurther develop and test tricycle manufacturing to generate a complete design and manufacturing handbook for our current and future partners.

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Wheels for the World

Prepared by Daniel C Gallagher, Ryan D Moyer, Joseph J O'Connell, Antonio G Ortiz, and Wesley N Ramirez

The Wheels for the World Team strives to create a practical mobility option for individuals unable to move on their own in developing nations. The device will allow the same mobility as a wheelchair while remaining affordable and practical. This project is working with Wheels for the World (an outreach of Joni and Friends) to create a design which will be capable of being mass-produced in the United States, shipped anywhere in the world in a box, and then assembled in the country of use.

A design has been completed which is similar to a tricycle with the third wheel in the back. This design uses bolts and platesto hold togethertelescoping square tubing as the frame of the design.A shock absorber system has been included to reduce the impacts from road variations. The design was developed to be fully adjustable to fit theuser and be fully collapsible for easy sotrage and transportation.

A prototype is being constructed. Design refinements will be made based on that prototype and an assembly manual to be distributed with the design will also be drafted and completed.

It is hoped thatWheels for the World will then begin distributing the design for field testing and then distributing it to developing nations throughout the world.

Design of Instructional Kits for STEAM Education

Prepared by Michael K Gray

The STEAM (Science, Technology, Engineering, Art, Mathematics) Education project aims to develop a kit that, in the spirit of the LEGO EV3 Robotics kit, is reconfigurable and designed with the intent to engage and educate middle-high school students. Unlike the EV3 kit, however, this kit will cost less than $100 and have individual “modules” that will communicate a specific STEAM concept (i.e. provide a visualization of how the Pythagorean theorem works, facilitate an interactive game that teaches the user to recognize particular musical tones, demonstrate how changing the variables in the circle equation affects the shape a circle, etc.).

Design of a Solar Power System for Ekuphileni Bible Institute

Prepared by Caleb H Bornman, Steven T Carpenter, Jessica R Kline, David J Moretz, and Joshua D Patterson

The Solar PV team works in developing countries to design and install solar arrays where the lack of reliable electric power hinders the missions of their clients. For their current client, the Ekuphileni Bible Institute (EBI) located in Mtshabezi, Zimbabwe, the local power grid fails often, preventing the school from providing optimal education to future church leaders. Frequent unexpected shut offs can last anywhere from a few hours to a few days at a time. This inconsistency means that EBI students are not able to use the computer lab, connect to the internet, use lighting for studying, or store food for fear of spoiling.

To provide a sustainable and long lasting solution to EBI’s current power issues, the Solar PV team will send five students along with Dr. Randall Fish and Engineering Projects Manager Derek Plante to install a five kilowatt system on the campus to provide power to their library, fridges, and classroom. The team leaves May 19th, 2017.

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Energy Monitoring and Management

Prepared by Austin T Kratz, David J Nicolais, and Nathan D Ressler

The Energy Monitoring and Management System facilitates access to electric power in regions with limited energy by increasing energy conservation and education. Our solution consists of a meter which allocates a configurable daily energy limit per facility, and a display that provides practical information to the user reporting how much energy they have used or have left before power is automatically cut off until the next day.

The current version of our system has successfully been installed in multiple facilities in Burkina Faso and Zimbabwe. We are currently working on troubleshooting and fixing problems that were discovered in the field. We are also working on a complete redesign of the user interface box, which was 3D printed in the past, but is now being adapted to allow use of a manufactured box. This new user interface design and updated software will be installed in Burkina Faso during the summer of 2017.

Pico Hydro: Powering Developing Communities with Run-of-Stream Hydroelectricity

Prepared by Shane D Braunworth, Andrew S Reedy, and Jonathan J Rogers

Many rural communities in the developing world lack access to basic utilities, such as electric power generation. The Pico Hydro project team has partnered with Engineering Ministries International (EMI) to develop a run-of-stream hydroelectric generator capable of generating 300 to 800 Watts of electrical power in communities that have access to a stream. The project team hastested three generator prototypes provided by EMI. With the results of those tests, along with research and outside sources, the team isformulating, constructing, and testing theirown design for a hydroelectric generator with improved cost and reliability performance.

Aeroponics

Prepared by Matthew L Brenneman and Erin Kelley

The Aeroponics Project aims to turn the western concept of aeroponics into something that can be made and used in developing contexts, such as those of our client, Open Door Development (ODD) in Mahadaga, Burkina Faso. While soil and available space are not the limiting factors, reducing the amount of water needed for agriculture leaves more available for the community to drink and use. ODD is not the only possible client, either; communities experience drought and limited water supplies all over the world, all the time. Our hope is that aeroponics systems can improve access to fresh food via a sustainable approach to agriculture.

Block Press: Providing Access to Sustainable Housing Solutions

Prepared by Adam T Janney, Addison A Morrone, and Brandon M Shirk

The Block Press project develops and tests mechanical presses to produce structural building blocks used for residential housing. Currently the project is serving a communityoff the east coast ofNicaragua. The indigenous people known as the Rama are migrating from the islandRama Cayto the mainland. The Rama are making this transitionthrough the help ofFriends In Action International. The press that the Rama had been using is too heavy to move in small boats and takes 3-4 people to operate. The project is designing a simple manual press that will only require1-2 people to operate. The presentation will focus on the prototype developed for the site team trip in early June 2017.

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Cumberland Pointe Futsal (Soccer) Project

Prepared by Sean P McCormick

CP Futsal is a project working with AROMA Missions to connect with a local community through sports at the Cumberland Pointe Apartment Complex in Mechanicsburg, Pennsylvania. The goal of this project is to build a facility that will also build relationships with the kids in the community. The CP Futsal team has developed conceptual plans, initiated a permit application, and prepared construction drawings to build a futsal playing area that resembles a sport-court soccer field.

Woodcrest Bridge Project

Prepared by Mark J Simpkins

The Woodcrest Bridge Project team is designing a cable-suspended bridge for Woodcrest Retreat, a Christian campground located in Ephrata, Pennsylvania. The bridge will span approximately 80 feet and will connect two hiking paths at the campground. Beyond its functionality, the bridge will be visible at the entrance to the campground, allowing it to be a site landmark feature of the retreat. Larson Design Group is partnering with the Woodcrest Bridge Team in the design and planning stages to provide professional review of our work. Additionally, Horst Construction is planning to assist with construction management to help build the bridge. The team is now finalizing the design and drawings to submit for building permits to allow for the start of construction later this year.

Straight Vegetable Oil Research

Prepared by Kyle M Doll, Ryan Kuhn, and Aaron W Ladeau

The BioFuels: Straight Vegetable Oil Research Team was created to provide our client with the research and information necessary to run agricultural equipment off of locally sourced Vegetable Oil or a Vegetable Oil-Diesel Mix to alleviate their dependence on imported Diesel fuel and help to support and empower the local economy. The creation of this project came from a request from our client Matt Walsh and his organization SIM that the Collaboratory continue its research into Bio-diesel fuel sources. The goal of this project is to be able to supply Matt with the information needed to run his diesel engines off a proven blend of vegetable oil and diesel fuel, and later to supply him with a standalone heating system that will heat the oil and allow him to further increase the percentage of vegetable oil that he is mixing into his diesel fuel. Although right now the goal is to supply this system to Matt and serve him as best as possible, in the long term there is potential to produce a modular fuel system that can be used across the world in order to ease the dependence on imported diesel fuel in the third world, and thus make energy more accessible to people everywhere.

Oakwood Hills Pedestrian Access

Prepared by Alex H Issis and Caleb C Stevens

The Oakwood Hills Pedestrian Access project seeks to provide an efficient and safe way to provide pedestrian access from Messiah College to future commercial development locations. This project serves the commercial developer, Rider Musser Development Corporation, and their land architect, H. Edward Black & Associates. This project allows students to design, develop, and construct solutions to this transportation problem that faces Messiah College students wishing to have pedestrian access to this new development area.

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Affordable Solutions to Pit Latrine Collapse

Prepared by Rachel L Aukamp

The objective of the Affordable Sanitation Team is to address the issue of pit latrine collapse in Northern Ghana. Pit latrines, holes dug into the ground which are used as restrooms, prevent open defecation and the spread of disease when implemented and utilized. Pit latrines should ideally provide a safe means for people to relieve themselves; however, most latrines are not lined and have a tendency to collapse due to soil pressures. Particularly during the rainy season, sandy soil becomes saturated, decreasing the stability of the latrine walls. Due to this issue of collapse, many people have fears of using the latrines that have been constructed in their towns and often revert to open defecation, which poses a significant problem. To prevent this reversion, World Vision has tasked the team with designing a latrine liner that will stabilize the hole while remaining affordable to communities in Northern Ghana. Over the past summer, the team visited the affected areas in Ghana and gained new direction for their work. Since this trip, four possible solutions have been considered: a plastic tub liner, a sand bag liner, a ferro-cement liner, and a rebar-reinforced fabric liner. Through testing and research over the course of the year, the plastic tub liner was rejected as a solution whereas the sand bag, ferro-cement, and rebar-reinforced liners were retained and developed. The team is now focused on optimizing the design of these three possible solutions with the hope of implementing these liners in Ghana next year.

Gravity Fed Water System

Prepared by Shung Yen Tan

The Gravity Fed Water Systems project aims to build a sustainable clean water filtration system with zero energy footprint for a village in rural Lombok Island, Indonesia in cooperation with Access Life International. ALI Lombok serves the poor in hilly rural areas by building clean water systems and has been doing so since 2013. The students on this project performed hydraulic design and analysis of the system, design of biosand filtration,and madesuggestions on system layout, pipe sizes, and other technical design to connect the spring capture to the ferrocement tank in the village allowing for clean, drinkable water on demand.

Intelligent Water Project: Remote Sensing of Pump Health for Promotion of Clean Water Access In Developing Countries

Prepared by Owen P McCullum, Kelsey E Nichols, and Sandra B Snozzi Solther

Millions of communities in developing countries rely on hand pumps installed by various non-governmental organizations (NGOs). Studies have shown that these pumps are often broken with significant delays before maintenance people arrive. The Intelligent Water Project (IWP) has developed an automated sensor to report failure of one of these hand pumps and provide data necessary for implementation of a proactive maintenance policy. Currently, there are 12 IWP systems installed in Ghana, Africa. This past year, the IWP team analyzed data gathered from these field units and implemented design changes to ensure functionality, increase serviceability, and prepare for mass production of the IWP unit.

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Mechanized Percussion Well Drilling

Prepared by Andrew C Dunmire, John P Hannon, Nathan A Henry, Cole D Hiduk, Althea G Mavros, Aaron D Mishler, and Greg M Shirk

The goal of this project is to develop and refine an efficient well-drilling system for a well drilling team in Burkina Faso, a small country in Western Africa. Our client is Matt Walsh, an SIM missionary and the founder of Open Door Development in Burkina Faso. With our total of 10 members on the team, we were able to work on a variety of components in the drilling process. This year, we were able to finish the design and manufacture our new superstructure and casing-pulling system, research new drill bit designs, and test our drilling equipment for a total of 60 hours. This summer, part of our team will travel to Burkina Faso to document conditions that will help perfect the components of our project.

Million Gallon Challenge

Prepared by Perri Katcher and David Patawaran

This project is assessing the long term performance of Sawyer PointOne hollow fiber membrane filters for point of use water treatment. The filters are fist-sized units that are used for camping and also as household filters. In the laboratory test, water is run continuously through twenty-four filters with hourly backflushing. The filters are periodically tested for bacteria removal.

Village Water Ozonation Systems

Prepared by Daniel Ma and Ted Sindabizera Ntwari

According to the World Health Organization, over 600 million people do not have access to clean water. Without clean water, people can contract waterborne illnesses, which can decrease the quality of life in the community. The Village Water Ozonation team pursues the ideal of providing communities with access to the cleanest water they can sustainably afford. Our work this year has focused on the development of two cost effective options for water sanitation: Biosand filtration and ultraviolet (UV) purification.

The UV system passes water through a pump, two filters, and a UV lamp that operates in the UV-C spectrum. The filters remove particles as small as 5 microns that can diminish the ability of UV light to contact pathogens. The light deactivates the DNA of pathogens, making them incapable of reproduction. The focus of working with this system has been to optimize the system for developing communities and to develop reliable ways to test for the system's efficacy.

The biosand filtration system is being designed to serve a school of 120 children in Honduras. The system will treat 60 gallons on a day. It is composed of fine sand, separating gravel, and drainage gravel layers. The sand media size plays a key role in the removal of pathogens. The focus of the work on this system has been sizing the layers to optimize flow rate and efficacy. The system's performance in terms of water treatment will be a subject of experiment in the Fall of 2017.