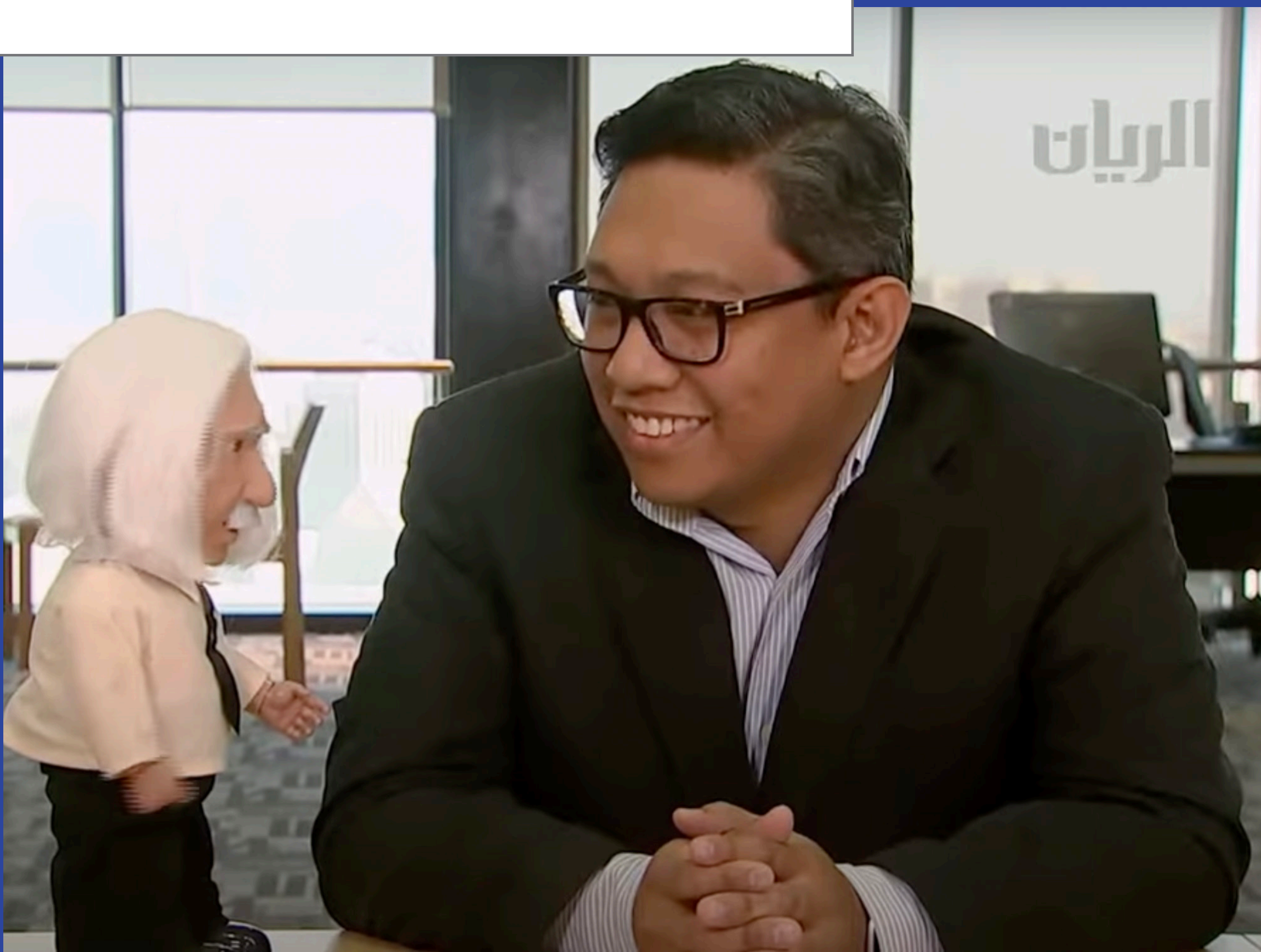
Research Portfolio

JOHN-JOHN CABIBIHAN, PH.D.



John-John Cabibihan received the Ph.D. degree in Bioengineering, with specialization in Biorobotics, from the Scuola Superiore Sant'Anna, Pisa, Italy, in 2007. Concurrent with his Ph.D. studies, he was accepted to the co-tutors PhD programme of the École Normale Supérieure Paris-Saclay, France. Therein, he spent one year with the Laboratoire de Mécanique et Technologie in 2005. In 2021, he completed the Venture Creation and Finance Programmes at the University of Oxford, UK.

From 2008 to 2013, he was an Assistant Professor at the Electrical and Computer Engineering Department, National University of Singapore, where he served as the Deputy Director of the Social Robotics Laboratory. He is currently an Associate Professor at the Mechanical and Industrial Engineering Department, Qatar University. He serves as the Program Coordinator of the Mechanical Engineering Graduate Program and a Member of the Faculty Senate (Research Committee). He is Lead Principal Investigator of several projects under the National Priorities Research Program of Qatar National Research Fund.

Dr. Cabibihan is among the top 2% of researchers worldwide according to the standardized citation metrics (2020). He is ranked #1 in Qatar, #4 in the Middle East, #228 in Asia, and #510 worldwide for the category of Industrial Engineering and Automation (subfield Artificial Intelligence and Image Processing). In April 2021, he was recognized as a Distinguished Scientist by Qatar University.

Welcome to my Research Portfolio!

My exciting journey in research started at Sant'Anna in Pisa as a PhD student in 2003-2007. I was fascinated by biomimetics and I wondered how our designs can be inspired by nature. I worked on bio-inspired tactile sensing, artificial skins, and robotic/prosthetic touch. At ENS Paris-Saclay (2005), I did my finite element simulation work and experimental validation of the time-dependent and hyperelastic behaviors of soft materials for artificial robot skins.

At NUS (2008-2013), I came in at the right time to work on social robotics, which was then at its early stages. I initially worked on the social aspect of artificial touch, which translated to applications for humanoid robotics and socially acceptable prosthetics. Some of the best works that I'm proud of is our work on the "Illusory Sense of Human Touch from a Warm and Soft Artificial Hand" (IEEE Trans. Neural Systems and Rehab Engineering, 2015) and "Physiological Responses to Affective Tele-Touch during Induced Emotional Stimuli" (IEEE Affective Computing, 2017). I then pursued a niche area on social robots for autism. Our 2013 work on "Why robots? A Survey on the Roles and Benefits of Social Robots in the Therapy of Children with Autism" is one of the most highly cited articles at the International Journal of Social Robotics.

Equipped with improved research skills and project management/leadership experience, my work at QU since 2013 expanded to a wider scope in multidisciplinary domains. I started investigations in surgical robotics and medical device design while adding my core strength to those with tactile sensing and haptics. Activities in prosthetics have also increased. We developed tactile textile sensors and neuromorphic algorithms for grasping and slip detection. My team refined our 3D printing capabilities for prosthetic arms. A direct application to that was our field work with the war-wounded refugees in Syria, in collaboration with the Qatar Red Crescent Society.

I continued my work in social robotics. We were granted a patent on a robotic train for children with special needs. It is a first-of-its-kind robot platform in social robotics. My team also did pioneering work on the prediction of aggressive behaviors of children with autism. We found that heart rate variability was a significant predictor of a child's meltdown. We extended our techniques in the detection of hypoglycemia in diabetic patients. We found that the heart rate variability obtained from a patient's wearable sensors was also a significant predictor. These were spinoff investigations from the physiological signal measurements on the affective teletouch work.

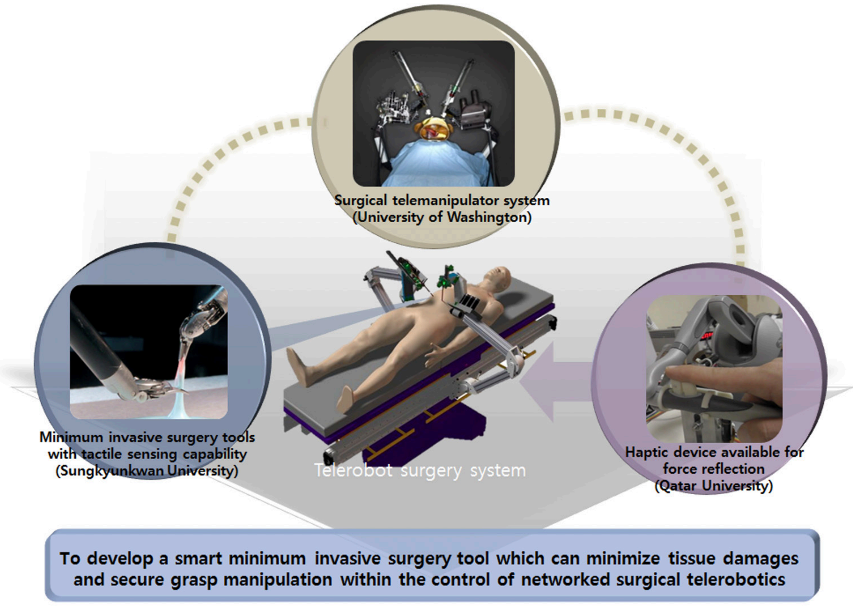
Still at QU, I collaborated with materials scientists to develop new materials and fabrication processes for sensors for various biomedical applications and technologies for renewable energy. I added a flair of biomimetics to those. I also collaborated with architects and civil engineers to develop new technologies for construction. Just like in social robotics, I found myself at the early stages of construction robotics. This early, we have already developed new end-effectors for robotic 3D printing and hot wire cutting.

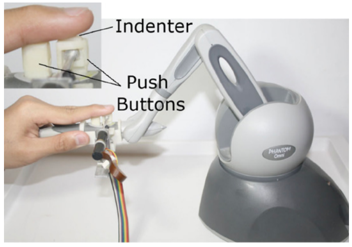
All these activities have attracted more than US$ 5.7 million in grants from various funding agencies. From these, 18 patent families and over 150 publications (journal articles, books, and conference papers) were produced. Using the ranking data from the 2021 Clarivate Journal Citation Report, 77% of my journal publications are in the Q1 (45%) and Q2 (32%) categories. Some of those works were featured by Nature Materials, MIT Technology Review, British Broadcasting Corporation (BBC), Popular Science, New Scientist, Discovery News, New York Magazine, and on the front pages of Peninsula Qatar. In June 2021, the government of Russia gave a special invitation to Qatar to exhibit at the St. Petersburg International Economic Forum. Our UV disinfection robot with telepresence control was selected as one of the showcased technologies.

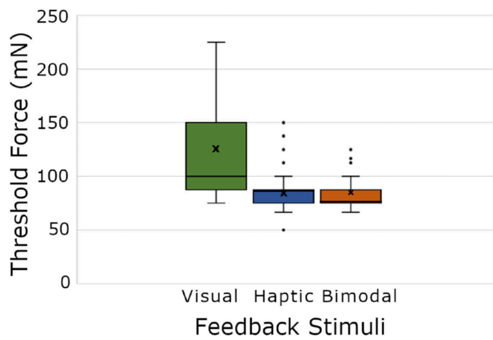
In the succeeding pages, I will givea brief description of my government/university-funded research projects together with what I think are the best representative images for each project.

John-John Cabibihan, Ph.D.
www.johncabibihan.com

Development of Smart Minimum Invasive Surgery Tools with Tactile Sensing Capabilities for Telerobot Surgery System





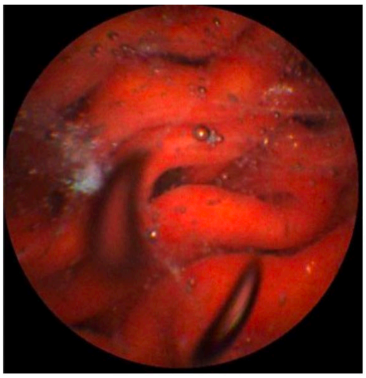


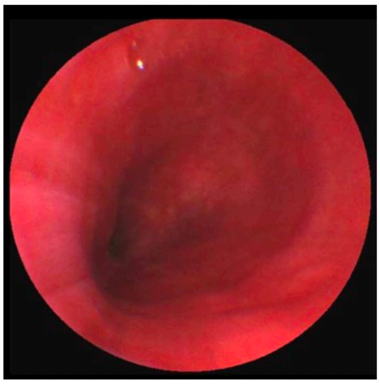
Lead PI: HR Choi
Co-Lead PI: JJ Cabibihan
PIs: WJ Yoon and B Hannaford
Funding: Qatar National Research Fund
National Priorities Research Program
Amount: US$ 1,018,554
Duration: 2012-2016

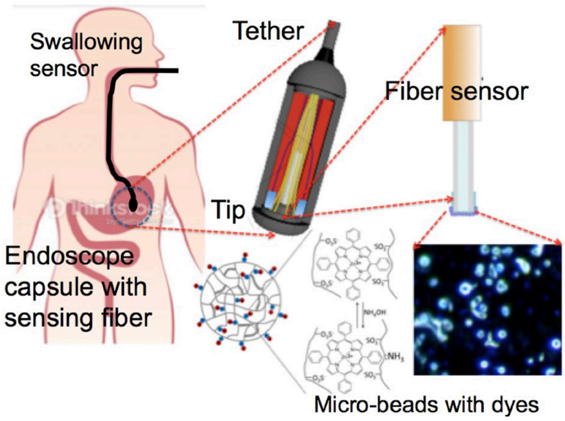
This project describes how a novel tactile/force sensing system, haptic device and imaging probe for minimally invasive robotic surgery (MIRS) were developed, and what outcomes were completed. Our project was aimed to develop a miniature multi-axial force sensor for integrating it into a surgical robotic system, a haptic device for reflecting the measured forces, and high articulated imaging probe for providing visual information. The developed prototypes were installed to an actual surgical robotic platform (Raven-II), and evaluated by conducting several surgery tasks.

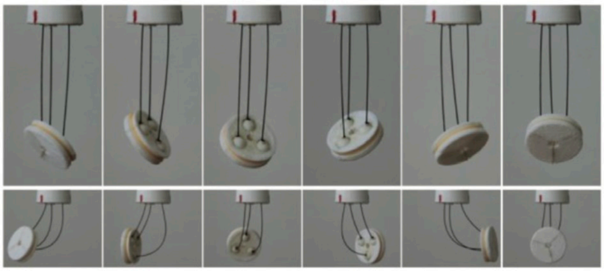
The miniature multi-axial force sensing system consisting of a three-axial force sensor was integrated to a surgical tool's wrist and a torque sensor was integrated to the tool base of the tool were built at Sungkyunkwan University. The haptic device and articulated imaging probe were developed at Qatar University and University of Washington, Bothell. At University of Washington, the surgical robotic platform was provided for evaluating the developed prototypes. As a result, the smart MIRS tool with the sensing, haptic, and the imaging system was developed and validated by conducting several surgical tasks.

Integrated Bio-Sensors and Automated Instrumentation for Early Stomach Cancer Detection Using Flexible Capsule Endoscope





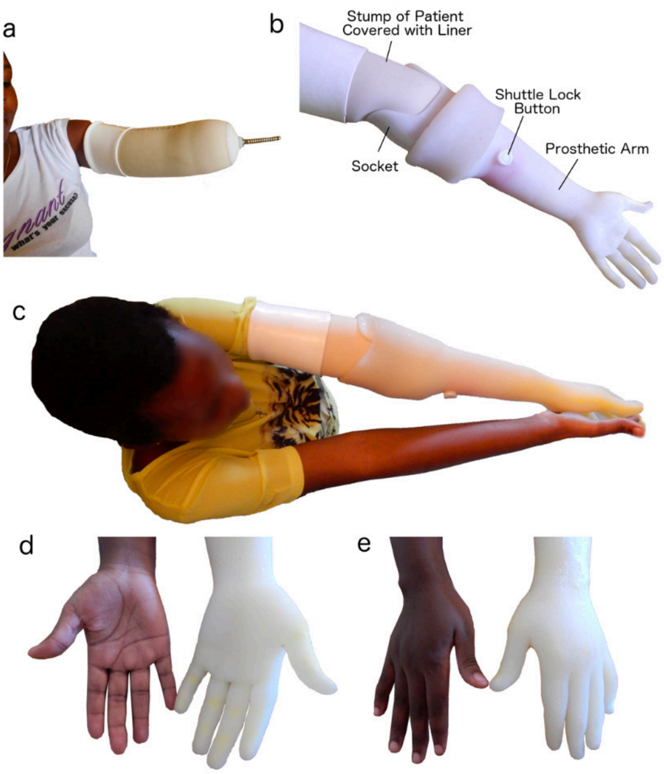


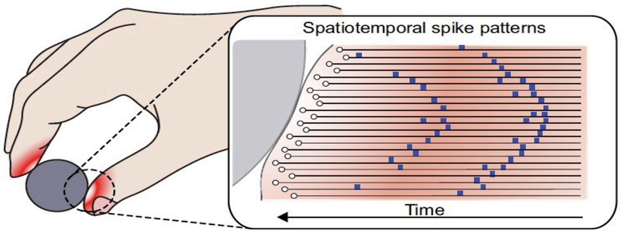


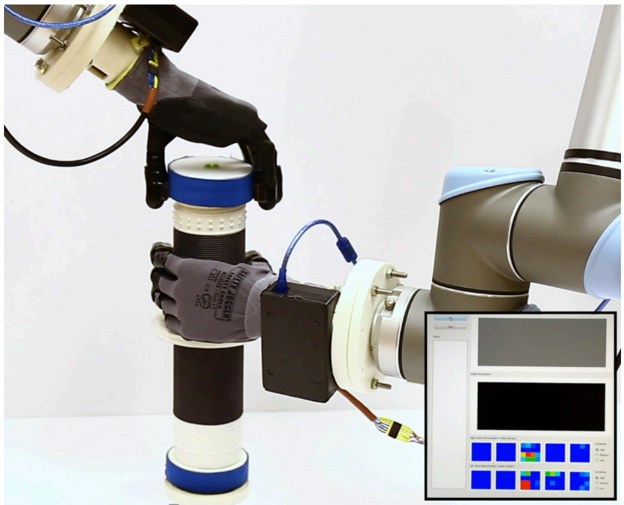
This project demonstrated a prototype of a Tethered Capsule Endoscope and a sensor that can detect the cancer biomarkers. The capsule endoscope (CE) technology can be a good alternative to the traditional endoscope in gastric cancer diagnosis. It offers reliable results without causing major discomfort to the patients. A steering mechanism was implemented to omni-directionally manipulate the capsule of a tethered capsule endoscope (TCE). The mechanism consisted of an actuator section containing three linear actuators, a thin and flexible tether, and a retractable capsule base. The results of workspace calibration showed that, when the capsule was fully deployed to a distance of 40 mm, it can cover 360 deg in the horizontal direction and up to 110 deg in the vertical direction. Along with the capsule, we developed a gastric gas sensor based on conjoined dual optical fibers functionalized with sensitive optical dyes for sensing gases in both fluidic and gaseous environment. The sensor aimed to sense various concentrations of carbon dioxide (CO_2) and ammonia (NH_3), which are two significant biomarkers of H. pylori infection in the stomach. The sensor prepared with optical dyes, cresol red ion pair and zinc tetraphenylporphyrin, were then embedded in silica beads and then functionalized onto the thin PDMS coated fiber tip. This sensor was easy to fabricate and was flexible in its construction. It achieved ppm level sensitivity to targeted gas analytes.

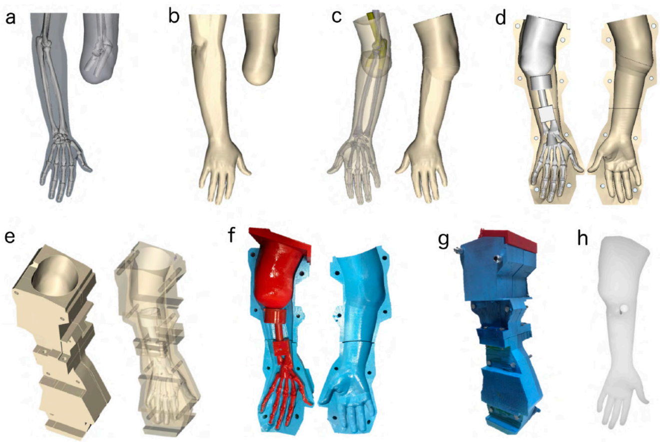
Lead PI: S Sonkusale
Co-Lead PI: JJ Cabibihan
PIs: WJ Yoon, E Siebel
Funding: Qatar National Research Fund National Priorities Research Program
Amount: US$ 1,035,523
Duration: 2012-2016

Neuromorphic Tactile Sensing: A Paradigm Shift for Prosthetics and Robotic

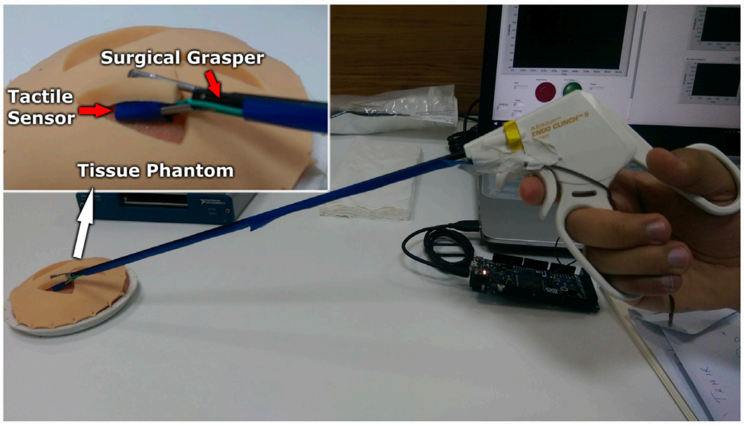


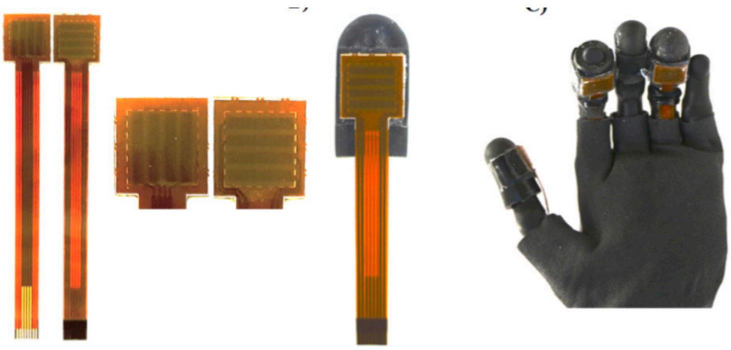






For a prosthetic hand or a surgical tool to be more responsive, a system that senses the external environment through contact is needed. This project achieved a transformative tactile sensing technology with properties that mimic the human skin and its tactile receptors to make a prosthetic hand or a surgical tool sense the environment. This system consists of a tactile sensing system that processes the sensor signals and converts them to neural firing patterns, and algorithms that will interpret the signals through brain-inspired learning mechanisms. The project was able to replicate neuromorphic tactile sensors to mimic human tactile receptors and produce spiking neural activity to encode touch information.



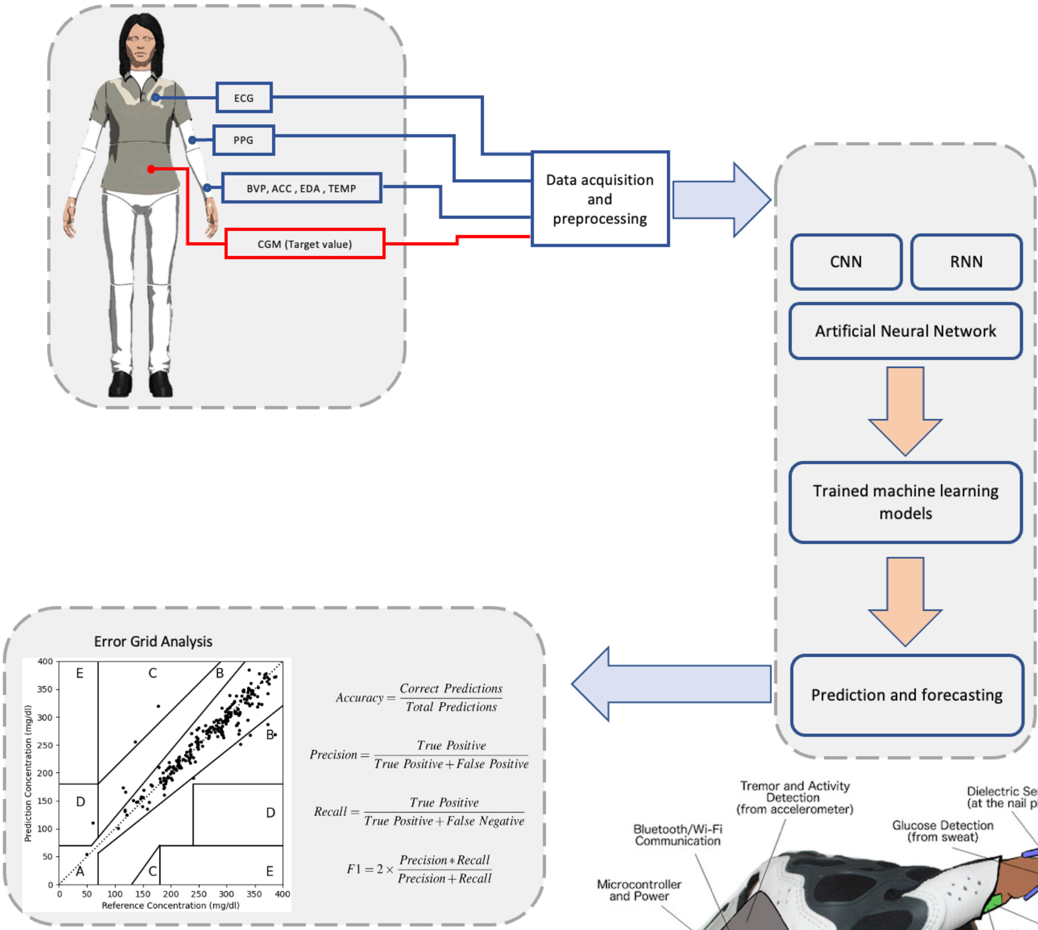


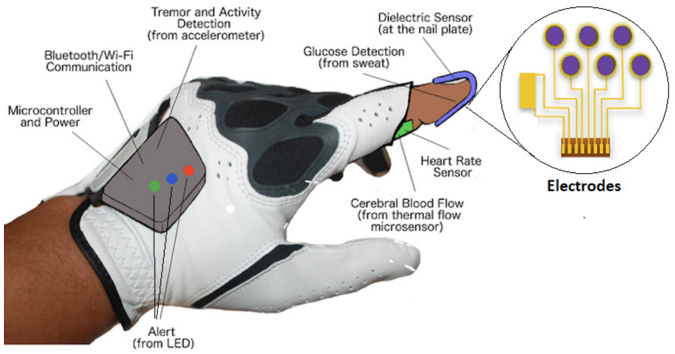
The tactile sensors that were embedded in biomimetic skin provided touch capability for the prosthesis and grasping tools for robotic surgery platforms. The project achieved the goals that we aimed to address. In this project, we developed: 1) a simulation model of the artificial skin; 2) artificial skin with tactile sensors at the nano and millimeter scales; 3) methods to provide encoding and processing of sensory information; and 4) the implementation of the tactile sensors to a prosthetic hand and to a grasper of surgical tool. Functional prosthesis can make a world of difference to amputees who lose limbs to traffic accidents, war, diabetes or other reasons alike.

Our international team brought in complementary expertise to solve an important societal and health problem of providing capabilities to modern prosthesis and surgical robots, and contribute to economic benefits by translating these ideas into practical and affordable sensors for worldwide use. This will translate into a paradigm shift in prosthetics and surgical robotics, serving the clinical need while making an industrial impact. Overall, there were at least 27 scientific deliverables consisting of patent applications, journal articles, book chapters, conference papers, and posters. Demonstrations were done in the presence of His Highness the Emir Tamim bin Hamad al Thani, and Her Highness Sheikha Jawaher.

Lead PI: JJ Cabibihan
PIs: N Thakor, A Al-Ansari, R Khaliki
Funding source: Qatar National Research Fund National Priorities Research Program
Amount: US$ 823,781
Duration: Jan. 2015-July 2018

A Noninvasive Monitor to Predict Hypoglycemia in Diabetes Patients

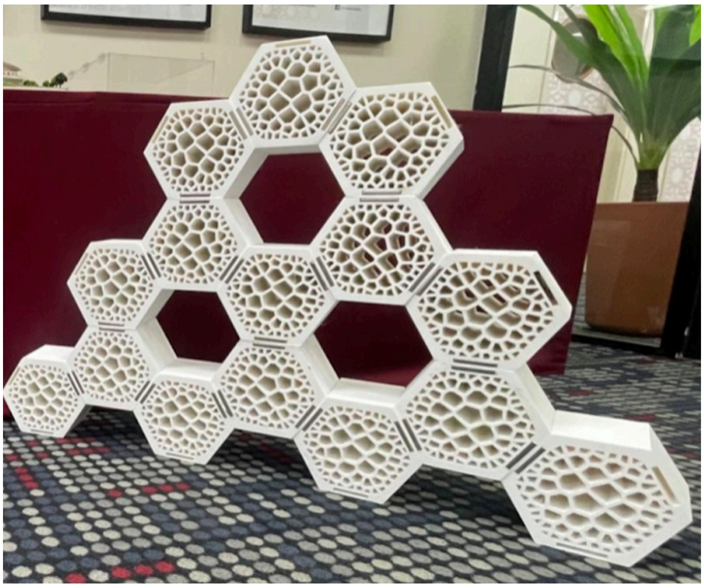


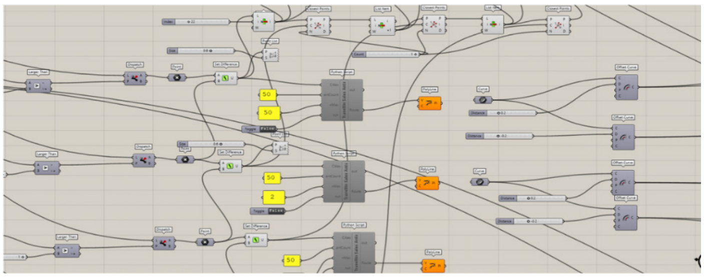


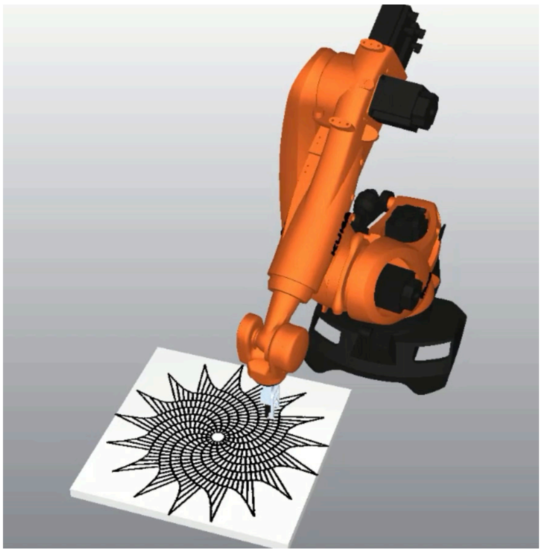
Lead PI: R Malik
PIs: JJ Cabibihan, KK Sadasivuni, AKAM Al-Ali, DHSH Al Mohanadi, KAM Baager, A Butler
Funding source: Qatar National Research Fund National Priorities Research Program
Amount: US$ 598,440
Duration: June 2019-May 2022

The identification of hypoglycemia among patients with diabetes (i.e., type 1 and type 2) is critical to reduce the risk of death and morbidity. This research project investigates several sensor technologies and machine learning techniques to monitor and predict hypoglycemia through the application of a non-invasive approach. The ability to predict the onset of a hypoglycemic event through non-invasive monitoring would have a major impact on the confidence of patients and their healthcare providers allowing glycemic control to be optimised and glycemic targets to be reached through more stringent diabetes therapeutic treatment regimens. A new non-invasive method to predict hypoglycemia through a wearable sensor may help prevent severe hypoglycemia by earlier recognition, and prevent morbidity and death. The activities involved in conducting the investigations in this research were as follows: 1) sensor development and refinement, 2) design and assessment of predictive models, 3) testing of noninvasive device in diabetes patients, 4) exploitation of the results, 5) dissemination of the results, and 6) project management and coordination.

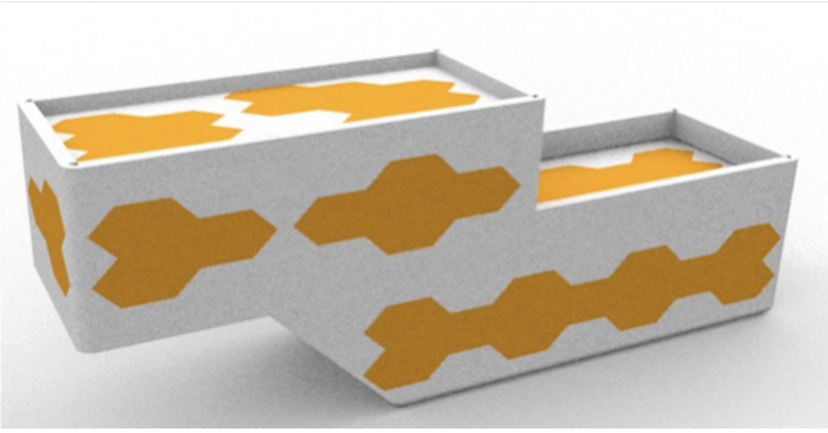
Qatar Robotic Printing

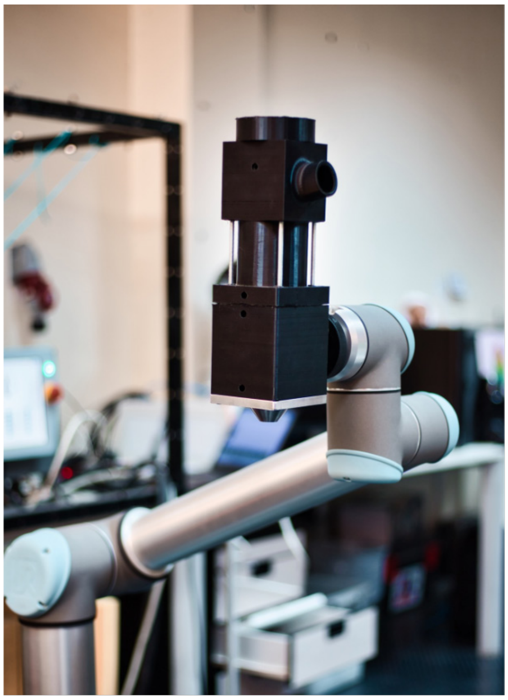






The core problem that is being addressed in this research is the actual inefficiency and unsustainability of design, structural optimization, materialization, building methods, assembly and climatic operation of commercial and residential buildings of today. The majority of realized homes, offices and institutional buildings are typically unsustainable in their outdated design to production methods. The QRP research will prove - by building prototypes and full scale parts of a building - that 3D printing using local resources will offer a highly competitive, efficient and sustainable alternative.





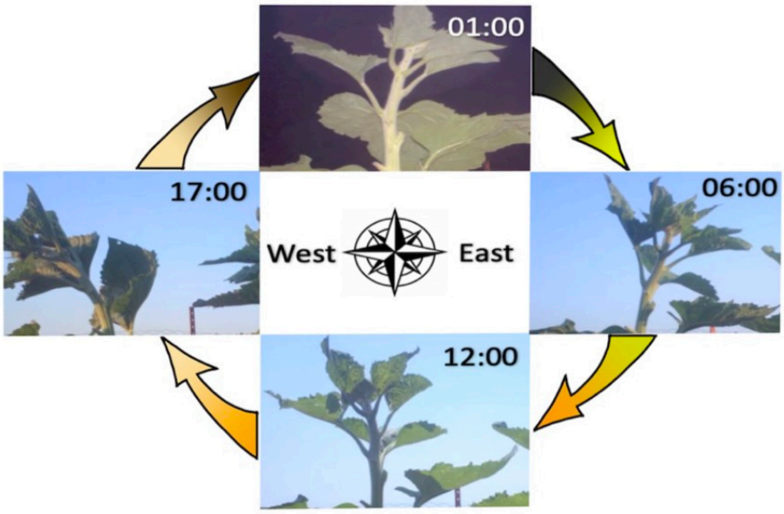
This QRP research aims at scaling up the 3D printing technology to the level of complete villas and buildings, to be based on a number of scheduled innovations in the field of: 1) lean parametric design to production processes, saving money time and resources, 2) improved material properties based on locally available and re-used materials to feed the 3D printing robots, 3) the smart integration of cultural-aesthetic, structural and climatic performance in the 3D printed building components, and 4) the assembly of prefabricated integrated 3D printed elements into large scale building complexes, by applying state-of-the-art principles of mass customization.

جامعة قطر
QATAR UNIVERSITY

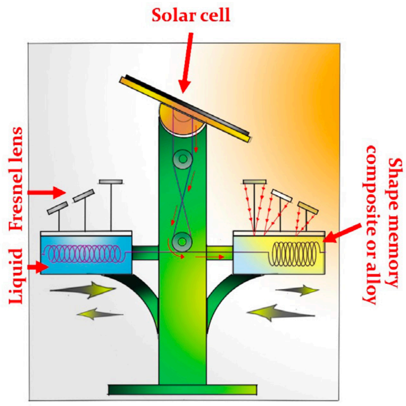
UTS
UNIVERSITY OF TECHNOLOGY SYDNEY

Lead PI: JJ Cabibihan
PIs: F Fadli, M Irshidat, N Biloria
Consultant: K Oosterhuis
Funding source: Qatar National Research Fund
National Priorities Research Program
Amount: US$ 579,120
Duration: June 2019-May 2022

The Sunflower Effect: A Bio-Inspired Approach for Heat-Seeking 4D/3D Printed Solar Cells



Growing demands for cleaner energy sources lead towards the innovations that demand investigations in solar power utilization. Though numerous organic and inorganic photovoltaic devices have been explored for the solar power conversion, achieving an efficiency of 100% is still an open challenge for the researchers. Efficiency is lower than 50% for almost all multi-junction solar cells. The high cost, seasonal solar radiation availability, difficulty to accommodate on the existing building designs, location-sensitive solar cell performance, and the low stability often hinder adoption and total reliance on solar power. In this context, an efficient, self-adjusting solar power panel coupled with low cost and high reliability is of great significance and demand.



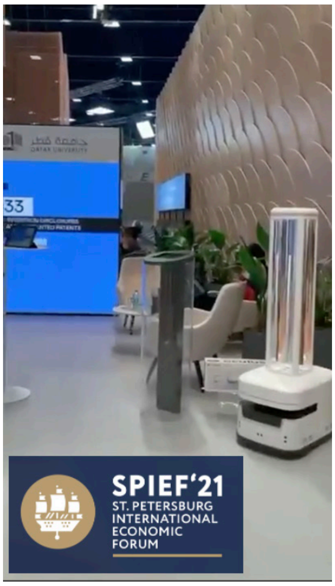
The project is developing a solar cell that can target maximum efficiency both by exploiting the materials performance to convert solar power and by utilizing the maximum available solar radiations through self-movement. The proposed solar panel will combine various pillars such as synthesis of novel nanomaterials based on semiconducting silica doped ZnO/ TiO2, development of new 3D printing (automation) device to spray coat these nanomaterials in to the form of large area solar cells, and the fabrication of shape memory polymer nanocomposites as a connector between solar cell and the cell metal support, by mimicking the sunflower movement.

As for the second phase, the shape memory polymer, polycaprolactone (PCL) or its co-polymeric nanocomposites are developed by coupling with MXenes/conductive filler nanosheets. This ensures improved shape memory property when exposed to thermal triggering. The fabrication of 3D printed PCL nanocomposites and its thermally triggered shape memory show the 4D printing influence. A set of Fresnel lens will be used to produce heat from the solar radiations and to couple with the solar cell/ shape memory support so that the sunlight can be maximally exploited to avoid the usual shadow overcasts.

جامعة قطر
QATAR UNIVERSITY

Lead PI: JJ Cabibihan
PI: KK Sadasivuni
Funding source: Qatar National Research Fund
National Priorities Research Program
Amount: US$ 599,640
Duration: Jan 2020-Dec 2023

UV Disinfection Robots in Public Spaces with Teleportation-based Control Schemes

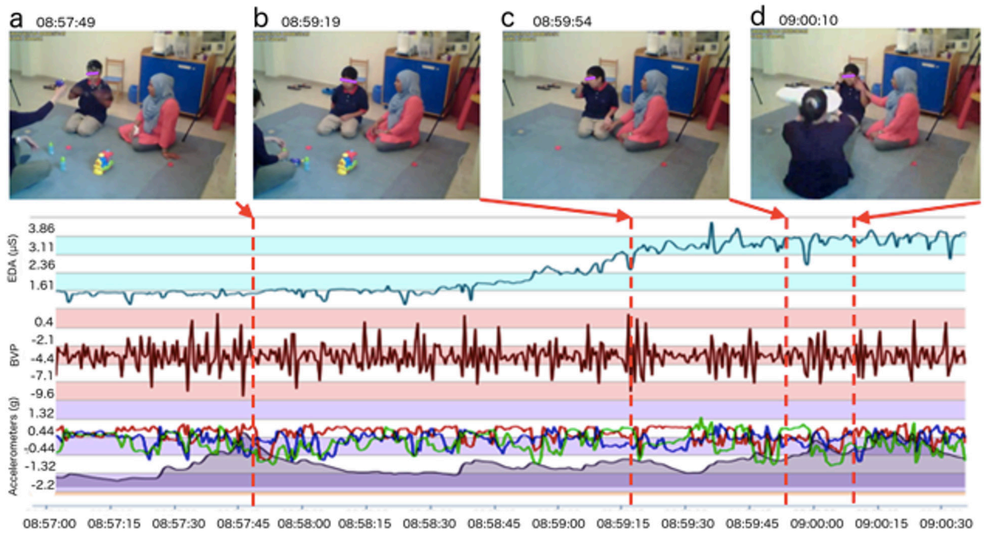


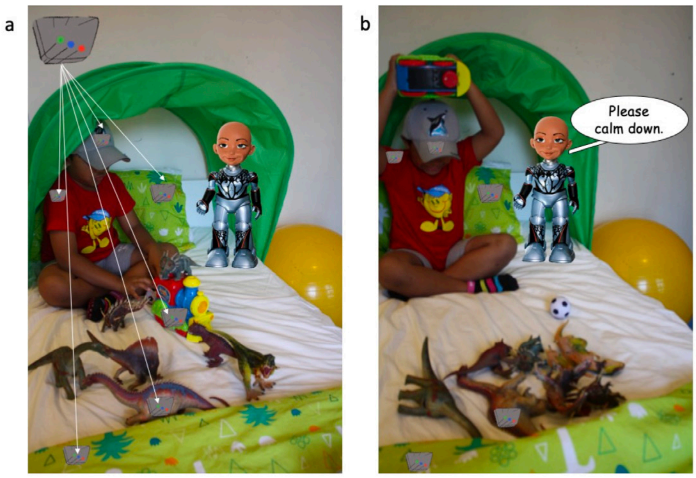
Transmission of COVID-19 is exacerbated by the ability of the virus to survive on surfaces for days after an infected individual was present in the area. For this reason, this project proposed a semi-automated disinfection approach utilizing ultraviolet technology to eliminate surface contamination in public spaces. Robot guidance was based on LIDAR that captured and analyzed the local environment and relayed visual input directly to the user, enabling remote navigation. For ease of control in large areas, destination selection was presented in the form of "teleportation portals" projected in augmented reality (AR). Object avoidance, movement, and disinfection were then completed independently by the robot. By deploying this device, our aim is to significantly reduce surface contact transmission of pathogen-borne diseases, including COVID-19.

جامعة قطر
QATAR UNIVERSITY

Lead PI: JJ Cabibihan
PIs: E Mahdi, AM Hamouda, S Gowid, M Al Hammami
Funding: Qatar National Research Fund
Rapid Response Call
Amount: US$ 27,937
Duration: June 2020-Sept 2020

Smart, Snap-on Device for Detecting Aggressive Behaviors in Children with Autism during Meltdown Events





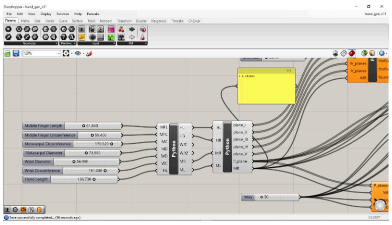
Parents, therapists, and caregivers have difficulty in predicting when meltdown occurs. Currently, there is no predictor of a meltdown event because the sources of the meltdown can be external or internal to the child. However, our earlier work showed that the increasing activity from objective measures (i.e. acceleration, heart rate, sweat rate, skin temperature) could be correlated to a meltdown event. In this project, we developed the core technologies to monitor the child when the meltdown occurs. More specifically, we accomplished the following: (1) A snap-on device was developed that can be attached to a child's clothing or toys. The device recorded the acceleration of a child's or toy's movements, and the child's screams, which was analyzed in real-time. (2) A machine learning algorithm was developed to classify whether the accelerations and screams correlated to a meltdown episode. (3) The device and the algorithm was validated on 10 participants at special needs schools in Qatar.

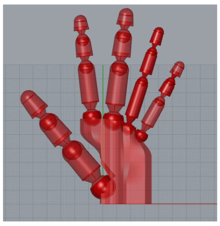
جامعة قطر
QATAR UNIVERSITY

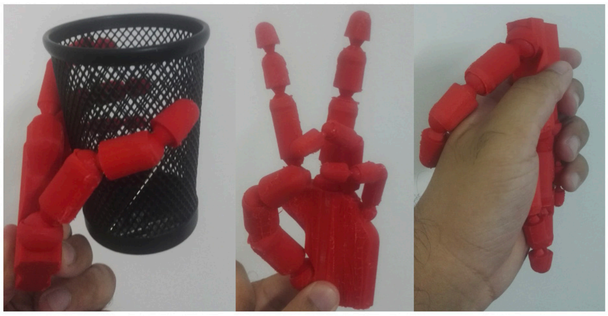
HANSON ROBOTICS

Lead PI: JJ Cabibihan
PIs: A Al Ali, KK Sadasivuni
Consultant: AK Pandey
Funding: Qatar University and Marubeni Corp.
Concept to Prototype
Amount: 150,137
Duration: Feb 2020-Dec 2021

Amputee-Driven Design and Development of Upper Limb Prosthesis using Virtual-Physical Methodologies







The trauma caused by limb loss has the potential to severely impact a subject's ability to perform activities of daily living. Prosthetic devices have been employed to provide users with some semblance of normality following such a life-altering event. Unfortunately, dissatisfaction with prostheses is prevalent, and the rate of non-adherence and device abandonment remains high. This has been attributed to the complexities associated with hand-object and a low consideration of patient preference during the development process. Clinical training and rehabilitation programs have been proposed as a means of easing the patient to using the device. Technological tools, such as virtual and augmented reality technologies are incredibly useful in such circumstances since they allow the patient to focus entirely on the required muscular training modules without the physical burden of a prosthesis at the early stage.

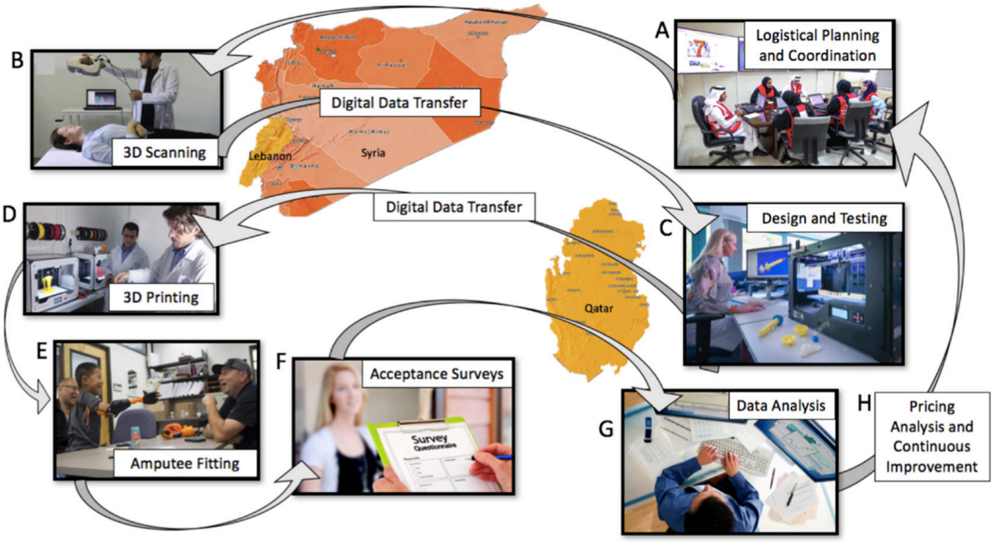
However, there is a lack of prominent experiments seeking to optimize this technology for the clinical setting. As result, this project delved into the literature in order to determine recent developments in the research, specifically with regards to the clinical implementation of virtual and augmented reality systems in upper-limb prosthesis training. This analysis showed a clear shift in the research favoring systems using combined structures and feedback mechanisms. Subsequently, the project sought to develop rehabilitation systems that fill this existing need by combining virtual interfaces, feedback and control structures, while also focusing on cosmetic appearances for the patient. By doing so, we establish clear pathways for future deployment of virtual training systems as well as the development of physical prosthetic models at a reduced cost.

جامعة قطر
QATAR UNIVERSITY

Universidade Federal de Uberlândia

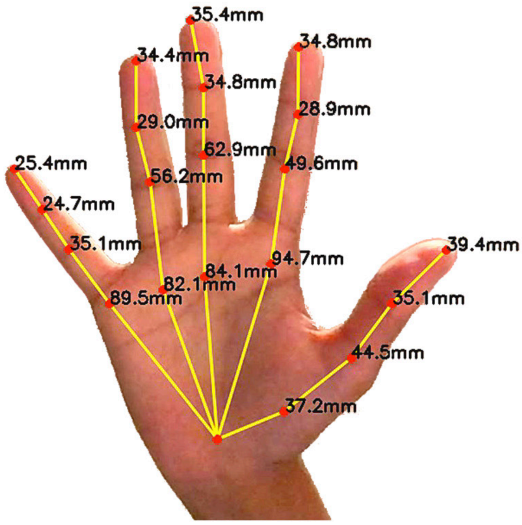
Lead PI: JJ Cabibihan
Qatar PIs: MR Paurobally, MS Ajimsha, MA Hammami.
Brazil LPI: AB Soares; PI: EA Lamounier Jr
Funding: Qatar University
International Research Collaboration Co-Funds
Amount: US$ 288,000
Duration: Feb 2019-Jan 2021

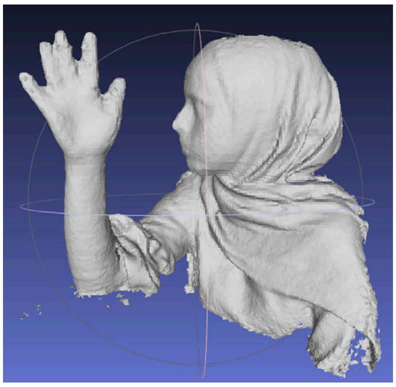
Extreme Reverse Innovation Process for the Delivery of Upper Limb Prosthetics via Digital Human Modelling, 3D Printing, and User Acceptance Surveys to Refugees

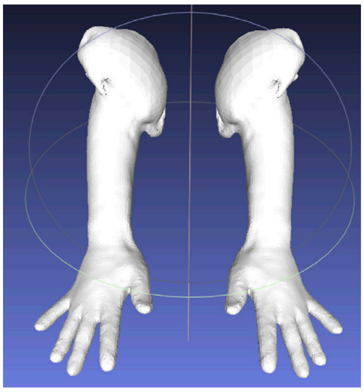


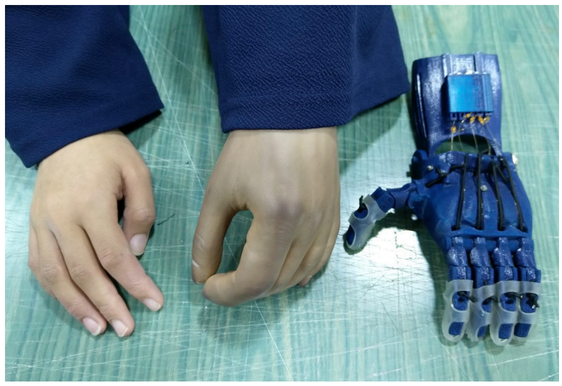
Our project aimed to conduct a trans-disciplinary research on the collaborative product and process development for delivering upper limb prosthetics to amputees and to survey recipient patients in order to learn by the user what are the pros/cons of these prosthetics and how it could be further improved. By building capacity in technological and humanitarian activities in Qatar, we anticipate contributions to a transformative eco-system in advanced yet affordable prosthesis through the synergistic collaboration among the scientific community within Qatar University.

For the first time, we embarked on a product and process development approach which we called Extreme Reverse Innovation whereby items (in this case, prosthetic devices) will be developed as low-cost yet functional and culturally-acceptable as possible in order to address the conditions of amputees in refugee camps. We envision that the resulting prostheses will serve as the core product where additional features can be adopted for amputees in both the developing and developed countries.









جامعة قطر
QATAR UNIVERSITY

INTERNATIONAL
FEDERATION

Lead PI: JJ Cabibihan
PIs: E Mahdi, LA Lambert, OS Al-Kwifi, K Diab
Funding: Qatar University
Collaborative and High Impact Grant
Amount: US$ 82,384
Duration: Jan. 2018-Jan. 2020

Our specific aims were (1) to determine the general technical requirements of the amputees and co-develop a plan for recruiting subjects in Qatar; (2) to develop a process to collect the dimensions of the amputees' injured and un-injured arms through portable 3D scanning; (3) to develop the upper limb prosthesis through computer modeling techniques. The computer-based model will be test-fabricated with a 3D printer; (4) develop a scientific survey to determine whether the subjects like/dislike the prosthesis and why; and (5) to conduct a pricing analysis and to study the costing and sourcing avenues for the raw materials to push the costs at the lowest possible amounts. If successful, our research and evidence-based approach to this problem can serve as a template for the rehabilitation of the war wounded in Lebanon, Syria, Jordan, and Turkey, where the State of Qatar through Qatar Red Crescent Society is extending their humanitarian assistance.

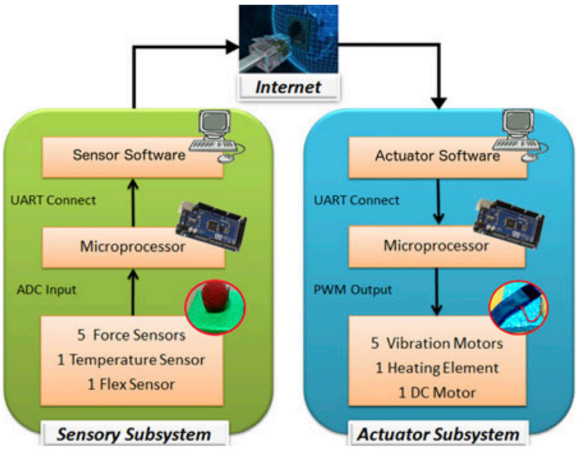
Robotics for Autism Assessment

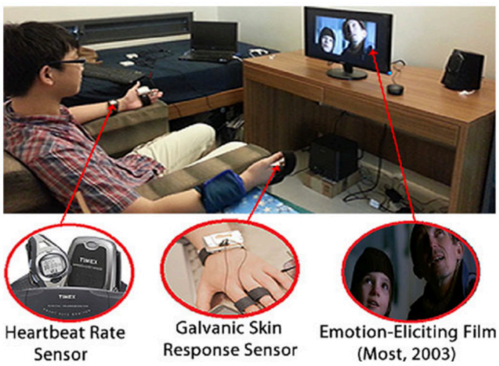
- ✓ Imitation
- ✓ Eye Contact
- ✓ Joint Attention
- ✓ Turn-taking
- ✓ Emotion Recognition
- ✓ Self-initiated Interactions
- ✓ Triadic Interactions

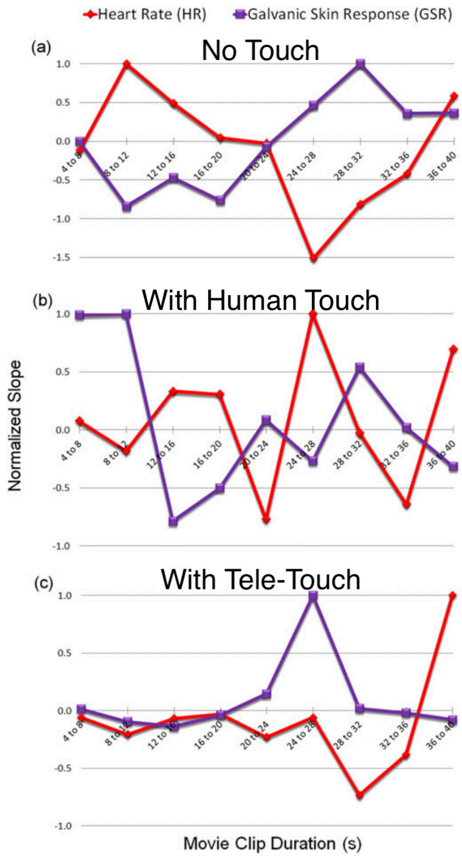
Principal Investigator: JJ Cabibihan
Collaborators: MH Ang, LF Cheong, SS Ge, TH Lee
Funding: National University of Singapore Academic Research Fund
Amount: US$ 141,376
Duration: Sept 2012-Aug 2014

We conducted research to investigate how robotics can be used for diagnosis and therapy of autism in children. Apart from this, we also investigated how robotics technologies can support the child with autism and his/her caregivers. Robots do not cure autism. However, there is an increasing trend showing that children have preference to interact with robots than to other humans. Earlier works have speculated that robots provide a less threatening environment than interacting with people. Furthermore, robots can provide a repetitive and more predictable environment. We can therefore use a child's affinity to robots so that the robots can serve as tools to connect with the children with ASD. In doing so, our scientific and technological insights will be able to complement other initiatives that aims to improve the quality of life of the children so that they too can be involved in society and contribute to the economic and social development of Singapore. Our activities on social robotics was visited by Pres. SR Nathan, former President the Republic of Singapore.

Affective Tele-Touch Technology







(4) The father sees his son falling to the machine room where the mechanism to raise the bridge and the emergency lever could be found.
(8) A caption that a choice must be made.
(12) Train passengers are shown unaware of what is happening at bridge control station.
(16) The first option is to leave the bridge raised. This will result into the death of train passengers, but the son will be saved.
(20) The son is shown as he is trying to free himself from the mechanism.

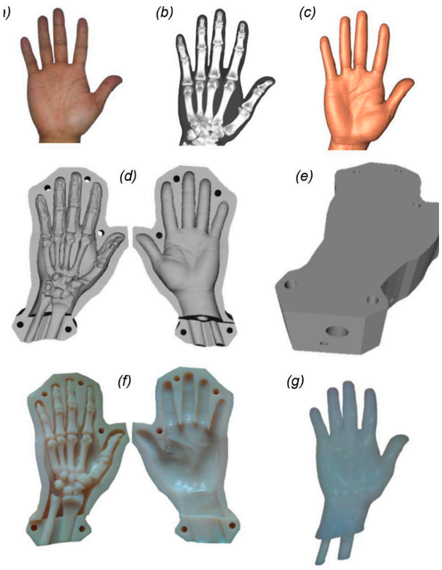
(24) The bridge is still raised.
(28) The second option is for the father to pull the lever in order to lower the bridge.
(32) The father agonizes over the decision.
(36) Continuation of the second option: pulling the lever will save the passengers but the son will be crushed.
(40) The steam from the train is shown, the train's horn is sounded. The train is fast approaching.

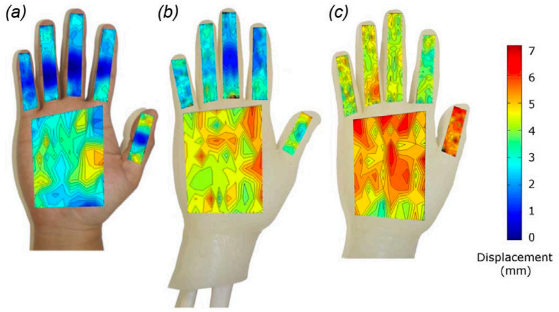
The human touch has long been recognized to promote physical, emotional, social, and spiritual comfort. There are situations, however, when touch cannot be exchanged. Although mobile phones and web-based communication are ubiquitous, touch—a communication modality that conveys powerful messages—is inexistent in modern communications media. This paper describes a tele-touch device that transfers affective touch to another person through the internet. Commands for vibration, warmth, and tickle were sent over the internet to a haptic device at the subjects' forearm. With a heart rate (HR) monitor and a galvanic skin response (GSR) sensor, the physiological effect of the tele-touch device was evaluated as the subjects watched an emotionally-laden movie. We compared these to one group of subjects who were touched by their spouse or girlfriend and to subjects of a control group where no touch was provided. Results show that the HR of the subjects with the tele-touch device was not significantly different from those subjects who were touched by their loved ones. These results were in contrast to the subjects who were not provided with any form of touch. On the other hand, the GSR results revealed that all the three touch conditions were different from one another.

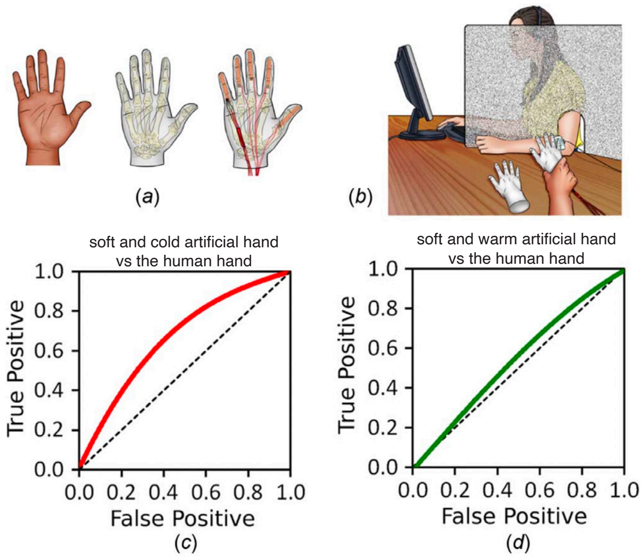
NUS National University of Singapore

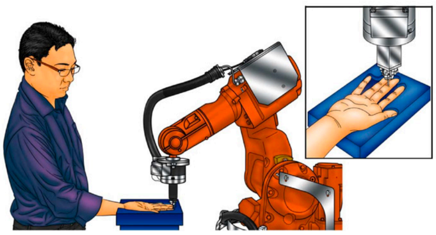
Principal Investigator: JJ Cabibihan
Funding: National University of Singapore Academic Research Fund
Amount: US$ 111,085
Duration: Feb 2010-Feb 2013

Design of Prosthetic Skins with Humanlike Softness









To touch and be touched are vital to human development, well-being, and relationships. However, to those who have lost their arms and hands due to accident or war, touching be- comes a serious concern that often leads to psychosocial issues and social stigma. In this paper, we demonstrate that the touch from a warm and soft rubber hand can be perceived by another person as if the touch were coming from a human hand. We describe a three-step process toward this goal. First, we made participants select artificial skin samples according to their preferred warmth and softness characteristics. At room temperature, the preferred warmth was found to be 28.4 deg C at the skin surface of a soft silicone rubber material that has a Shore durometer value of 30 at the OO scale.

Second, we developed a process to create a rubber hand replica of a human hand. To compare the skin softness of a human hand and artificial hands, a robotic indenter was employed to produce a softness map by recording the displacement data when constant indentation force of 1 N was applied to 780 data points on the palmar side of the hand. Results showed that an artificial hand with skeletal structure is as soft as a human hand. Lastly, the participants' arms were touched with human and artificial hands, but they were prevented from seeing the hand that touched them. Receiver operating characteristic curve analysis suggests that a warm and soft artificial hand can create an illusion that the touch is from a human hand. These findings open the possibilities for prosthetic and robotic hands that are life-like and are more socially acceptable.

Principal Investigator: JJ Cabibihan
Funding: National University of Singapore Academic Research Fund
Amount: US$ 141,342
Duration: July 2008-July 2011

Let's Connect

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