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2019/2020 Ideate-Prototype-Realize


SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Simon Perrault | Advisor

Designing Disembodied Conversational Agent to Communicate Empathy to Lonely Senior Citizens

Problem Statement

Senior citizens living alone have very **minimal interactions** outside homes and some of them are restricted due to mobility issues or have a reduced group of friends to interact with it. This creates **loneliness in their lives** and could affect their health in the long run. Loneliness has been identified to cause other disease such as Depression, Alzheimer's and could also worsen their current medical conditions.

Research Questions & Hypothesis

RQ1: Why are the lonely senior citizens not interacting much and isolated?
(i) What are the accessible modes of communication available for them to communicate?
(i) What kind of interaction will help a lonely senior citizen with loneliness?

H1: Lonely Senior citizens that interact with someone for at least twice a week have a reduced amount of depression or loneliness.

RQ2: What are the challenges in designing a communication system that communicates care and empathy?
(i) How are conversational agents commonly used right now in the industry?
(ii) What is the current communication style and system that a conversational agent adopts?

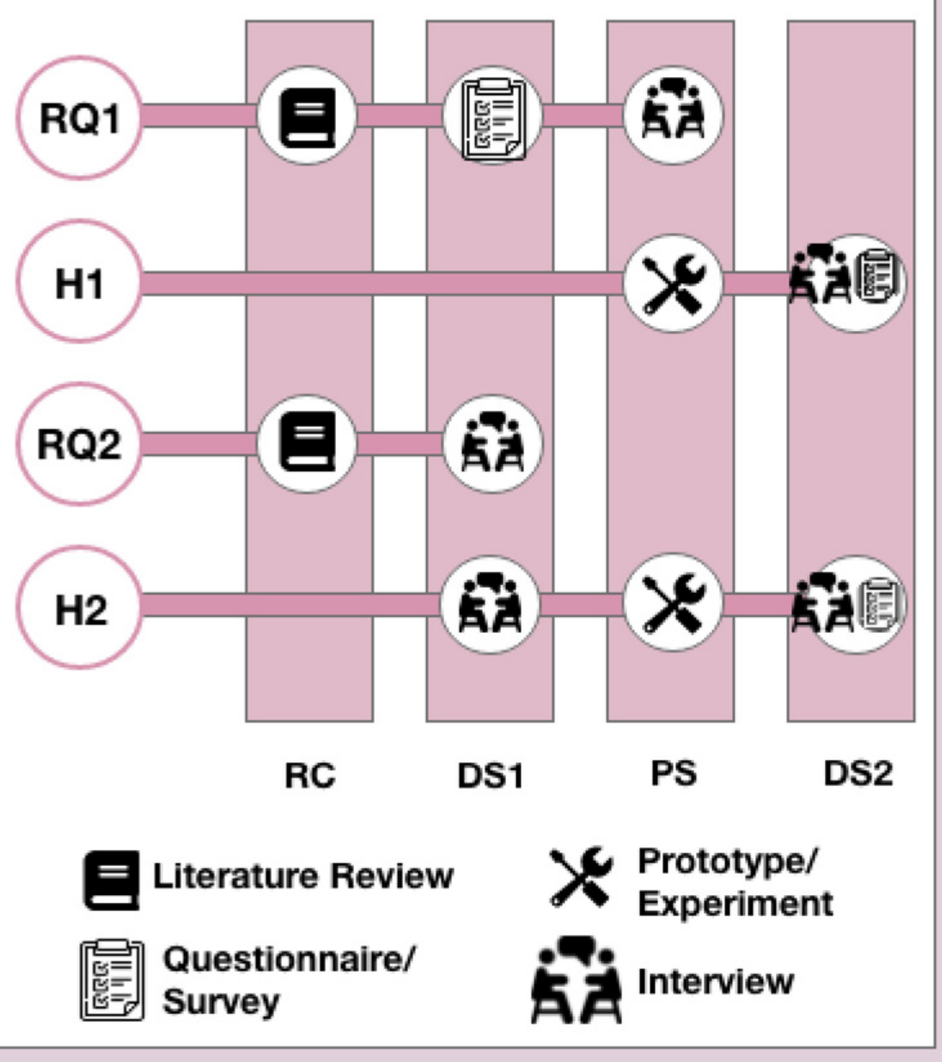
H2: A simple and easy-to-use communication system allow Senior Citizens to use the product with little effort.

Research Aim & Goal

The **Aim** is to help senior citizens reduce the amount of isolation that comes with living alone and help them to interact more to avoid health issues that comes along with loneliness.

The **Goal** is to develop a chatbot that allows Senior citizens to communicate with them instantly using their smartphone. The chatbot should communicate care and empathy to make them feel cared and happy.

Research Approach



Expected Contribution

Academic
The Research is expected to enhance the understanding in designing a conversation agent to communicate empathy. As most conversational agents are still in the stage where the responses are robotic and scripted, the research will provide a better understanding and method towards designing a better conversational agent to communicate empathy.

Industry
Successful Implementation of the conversational agent will provide an avenue for lonely senior citizen to interact. Community organization can only make use of product to keep regular check on senior citizens living alone without constraining too much manpower for home visits.

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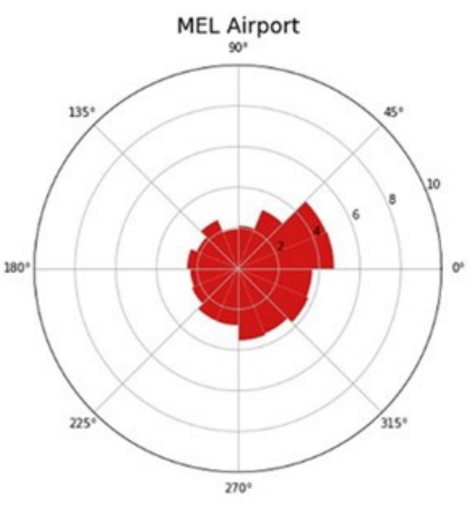
Ahmed Meeran | Student

Sam Conrad Joyce | Advisor

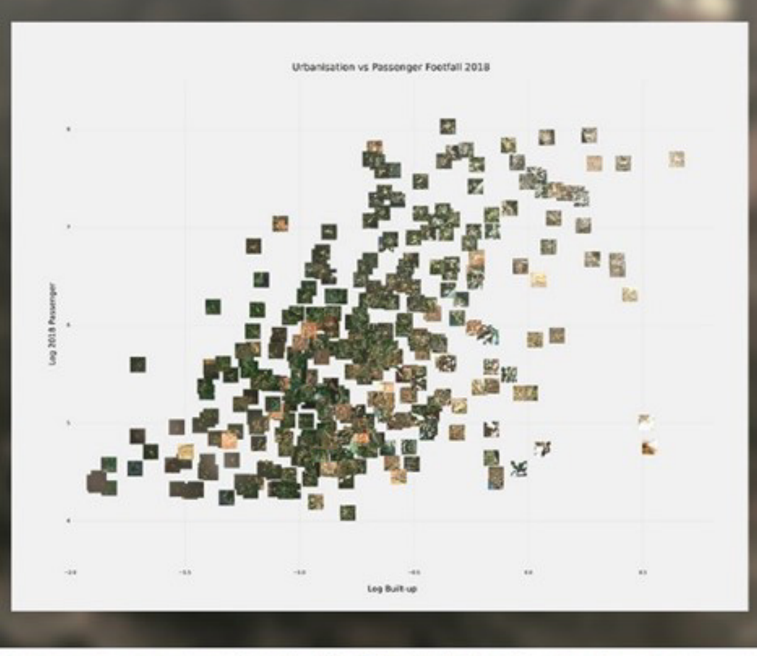
Aviation has historically been one of the most consistently growing industries. With global 5.4% growth year-on-year over the last two decades representing a 15 year doubling period of passenger numbers resulting in many airports being built. However in 2020, aviation was one of the worst hit industries due to the global pandemic, before that seeing resistance due to its contribution to global warming. This has led society to consider wide spread and potentially radical transformation in aviation to maintain its sustainability.

Airports can be disruptive, expensive, and take long to build; and when operating result in land use, exposure to noise and environmental degradation but equally enrichen cities, society, culture and economies. The lack of readily available data for airport planning and design can be a problem for governments and decision makers especially in developing economies where many aviation projects are currently being realised. This research project aims to tackle this problem of data discovery and availability for large scale urban infrastructure entities through Machine Learning and advanced GIS Analytics.

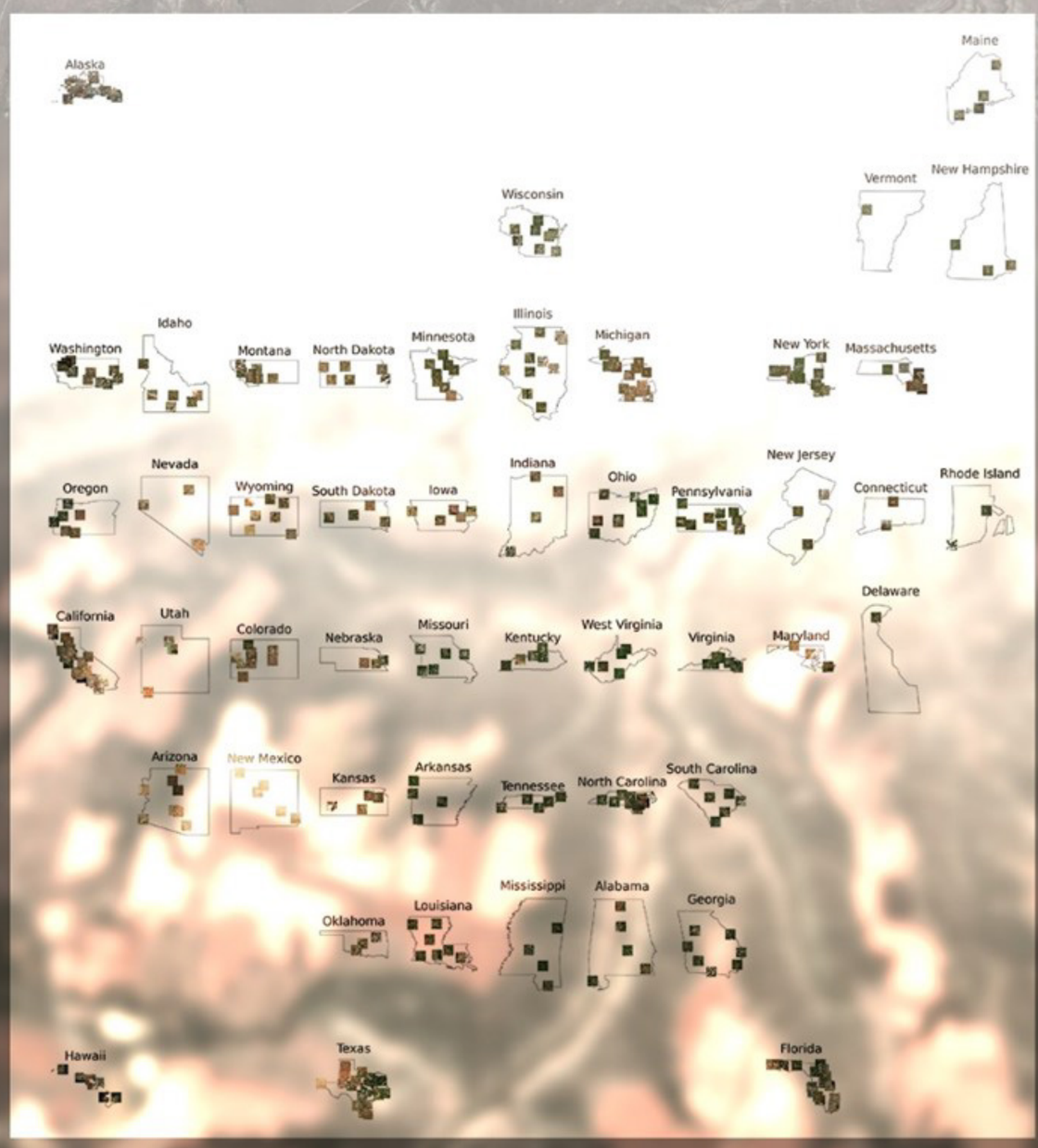


Focusing on aerial image analysis we use open access satellite imagery data on the world's top 1000 airports (based on passenger footfall in 2018), and explore key typology based questions specifically: airport expandability, land encroachment, and interaction between urban zones and airport activity. The approach is a scalable methodology that can be applied to many airport sites: to explore though comparative data, current impact of airports on existing land usage, if airports could expand or contract, and how beneficial or challenging it would be to do so.

A U-Net Architecture was used to train all the 1000 airport images, using 50 cherrypicked sample images which were masked manually to represent the geographical features such as Built-up (red), Arid (yellow), water (Blue) and empty land (Green). The 50 images were strategically chosen to broadly represent the entire dataset in terms of geography, size of the airport, cloud coverage and level of urbanisation surrounding the airport.



Correlation between Passenger footfall and urbanisation of airport showing a trend between the two, indicating the possible scope for expansion of a few strategic airports.



Oslo International Airport visualised across seasons over a year

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Amalina Zafirah Hashim | Student
Prof. Lynette Cheah | Advisor

REDUCING FRUIT & VEGETABLE WASTAGE IN COMMERCIAL KITCHENS

IDEATE | PROTOTYPE | REALIZE

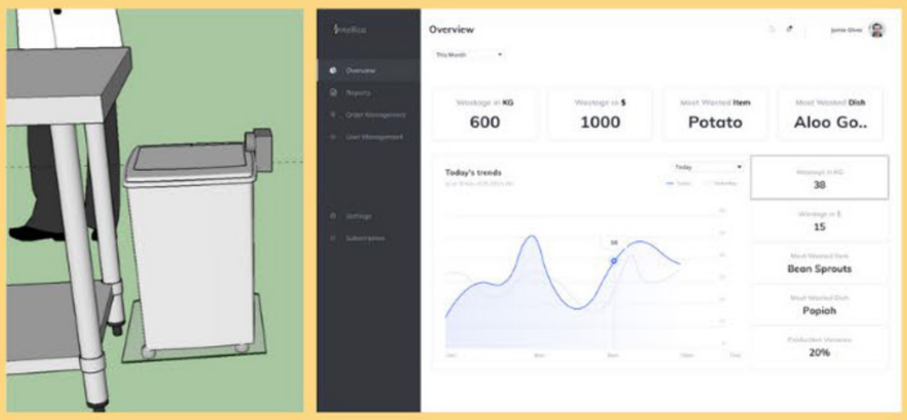
Introduction

Food Wastage is a global problem and affects Food Security. Currently, data collection is a challenge due to the manual process involved and inaccuracy of recording information by kitchen staff. The few available solutions in the market are expensive and require change to operational workflows; in which Foodservice owners are resistant to adopt.

Ideate

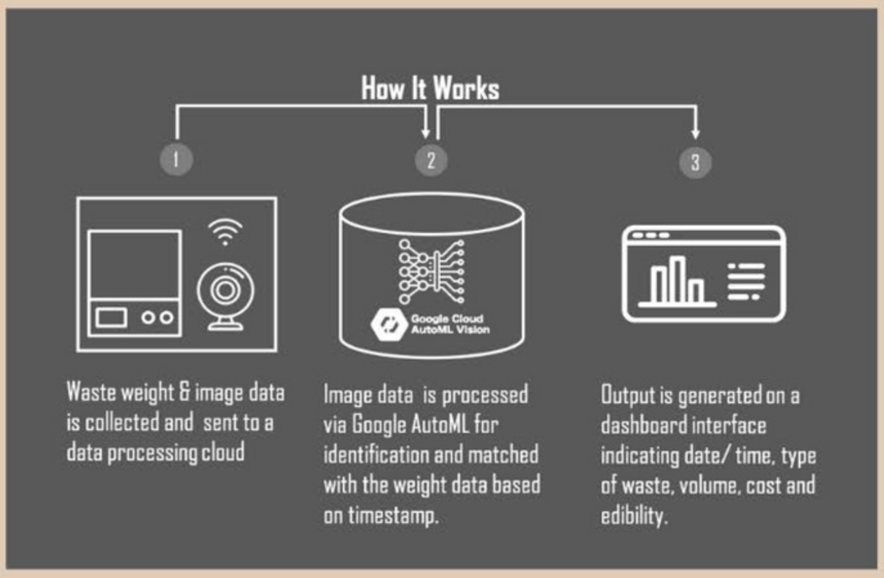
Through a *Discovery* process of Industry Observations, Interviews and Environmental Scan of potential solutions, we *Defined* the ideas that would address pain points identified in the user journey and arrived at the following Problem Statement: **How might we design a simple & economical method to measure waste so that over-ordering can be reduced & order demands better predicted.**

Prototype



In refining the *Design* of the solution we conducted a Needs Analysis through the Affinity and Activity Diagram exercise to produce the Feature Requirements. Solution concepts were sketched and the winning idea brought forward for further development into a prototype that could illustrate how the solution worked. The prototype was tested for user feedback and further refinement.

Realize



In this last phase we begin to *Develop* the Final Specifications that will be used to produce a functional prototype that can be used in a real user environment. Live data can be collected to prove or disprove that indeed a simple & economical wastage measuring tool can help reduce over-ordering and predict demand better.

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Ashreya M Venkatesh | Student
Dr. Kristin Lee Wood | Advisor

Motivation

How Might We [HMW] measure and plan for Design Impact, across disciplines and scale?

- Organizations seek systematic approaches to measure Design Impact
- This must be more than "you know when you see it"

Research Questions

- **What are the current ways which design impact is measured?**
- **How is design impact measured across disciplines and scale?**

As a tangible and extended idea of Design Impact, four Impact Areas were identified to constitute the framework.

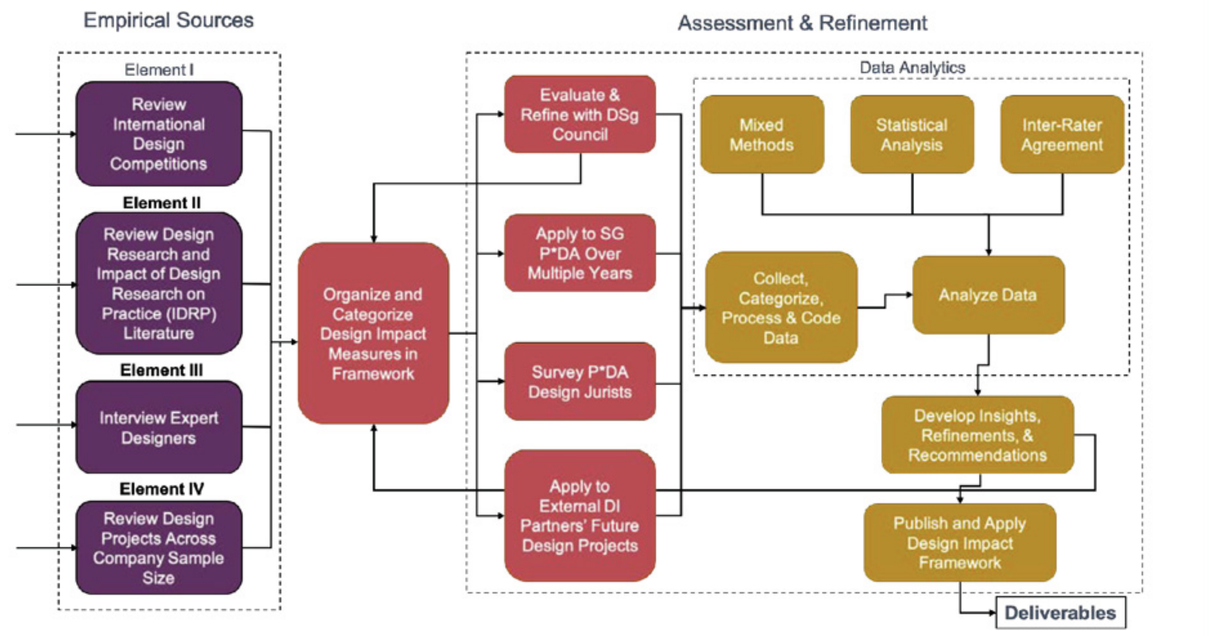
A. Enabling Economic Transformation
B. Raising Quality of Life
C. Advancing Brand, Culture and Community
D. Making Ground-breaking Achievements in Design

Outcomes and demonstrators were developed to help define and assess each impact area.

The framework has been used through 2 rounds of the President's Design Award competitions in 2018 and 2020, with more than a 150 design applications submitted each year. 58 projects have been shortlisted using this framework.

The design fields of these projects range anywhere from landscape design to UX design to architectural design.

- The following is the overall research methodology. We reviewed empirical sources as stated to see what has already been done. This was then organised and categorised into a framework.
- And then we go into the assessment and refinement stage where we evaluated and refined with the DesignSingapore Council (DSG).
- This was also applied with President's Design Award (PDA) over several years.
- Feedback was collected from the PDA design jurors.
- The data from these were then collected, categorised and analysed to develop insights, refinements and recommendations.



Enabling Economic Transformation

Improve internal processes/systems	Enhance employee's experience	Generate positive outcomes
• Save operating and service costs • Save resources for the company or organization • Demonstrate effective co-creation with users or stakeholders • Make a process more efficient or effective • Shorten task completion time (efficiency in some task or work) • Include inherent functionality for - future improvements, - quick product-service-system development cycle time • Reduce failure potential (likelihood/severity) • Increase in ability to predict/detect and overcome failure modes • Provide intellectual property protection	• Elicit positive emotion • Increase in safety in usage (or other factors such as manufacturing) • Facilitate a short or virtually zero learning curve • Address or enhance the usage across assistive technologies (inclusion of persons with disabilities or the elderly) • Integration of cutting edge technology that makes a difference	• Enhance brand reputation • Increase in market share • Increase in adoption rate • Increase in revenue • Empower/teach user • Improve user health • Lower living or work-place costs or save time for user • Increase in sales and/or potential sales • Increase customer, user or stakeholder satisfaction • Add a new capability • Simplify usage/increase efficiency • Garner positive ratings in Consumer Reports • Environmental responsiveness and sustainability
• Integration of cutting edge technology that makes a difference		

Advancing Brand, Culture and Community

Increase identity and bonds with country and/or community	Provide new perspectives, ideas, or contributions on culture	Make a community stronger, more efficient &/or more effective
• Enhance brand reputation • Enhance culture, community, or society • Engage various community sectors • Execute volunteer or outreach programs • Promote understanding or create engagement across cultural groups	• Demonstrate co-creation with Singaporeans or user groups • Persuade or motivate user in a positive manner • Promote volunteerism or philanthropy • Increase in sustainability • Improve environmental impact in Singapore • Address or enhance the usage across assistive technologies (inclusion of persons with disabilities or the elderly)	• Provide high user satisfaction • Improve lives (in terms of happiness, time savings, finances, health, play) • Add a new capability • Improve a process • Integrate well into the system or environment of usage (compatibility) • Environmental responsiveness and sustainability
	• Integration of cutting edge technology that makes a difference	

Raising Quality of Life

Make daily tasks more convenient	Enhance living experience	Provide opportunities for improvement of lives
• Save time • Add a new capability • Facilitate a positive learning experience • Improve a process • Integrate well into the system or environment of usage (compatibility) • Simplified usage and user experience, such as reduction in number of tasks or task difficulty • Improve use physically, cognitively (e.g., enhanced RULA score)	• Provide high user satisfaction • Reduce costs • Empower and/or teach the user • Achieve significant positive impact on day-to-day living • Enhance aesthetics or interactions for better experience • Facilitate expression by and for community(ies) • Increase in safety in usage	• Create greater happiness/positive emotion • Enhance culture, community, or society • Persuade or motivate user in a positive manner • Increase sustainability • Improve environmental impact • Garner positive ratings in Consumer Reports • Reduction in failure potential • Address or enhance the usage across assistive technologies (inclusion of persons with disabilities or the elderly)
• Integration of cutting edge technology that makes a difference		

Making Ground-breaking Achievements in Design

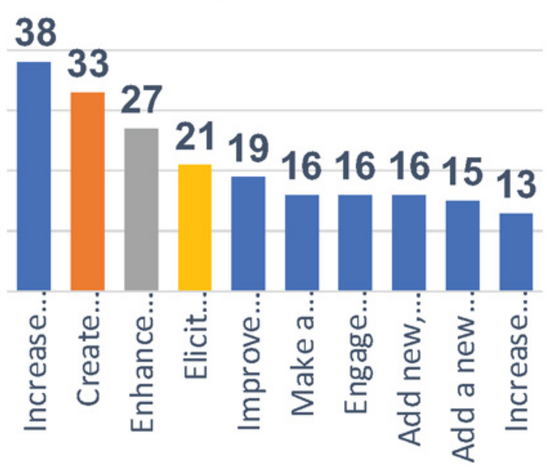
Innovate a process (design, manufacturing)	Provide a new type of outcome	Exemplify exceptional design	Transform culture or a community
• Make a process more efficient or effective • Facilitate a positive learning environment • Introduce a new or improved process with high adoption rate or coverage • Introduce a new or improved typology with high potential for adoption or coverage	• Add new, unique capability for users • Provide high user satisfaction • Attract significant attention such as through media or social outlets • Shorten task completion time or make task more convenient • Enhance or establish brand reputation • Increase revenue, market share and/or adoption rate	• Include inherent functionality for future improvements • Shorten product-service-system development cycle or deployment time • Integrate well into the system or environment of usage (compatibility) • Reduce operating or service cost • Reduce failure potential • Address or enhance the usage across assistive technologies (inclusion of persons with disabilities or the elderly) • Garner positive ratings in Consumer Reports • Increase sustainability • Improve environmental impact	• Improve people's lives (happiness, time or cost savings, connections to family or community, health, play) • Demonstrate effective co-creation • Teach, persuade, motivate or inform users • Enhance culture, community, or society
• Integration of cutting edge technology that makes a difference • Environmental responsiveness and sustainability • Impactful. Desirable and Useful Design Content			

Analysing the projects from 2018 and 2020 submissions:

There are a total of 57 unique Demonstrators
And they have been used a total of 442 times

4 out of 4 (100%) Impact Areas
13 out of 13 (100%) Outcomes
53 out of 57 Demonstrators (93%) were used at least once

The Top 10 primary demonstrators are shown in the table below with "Increase customer, user or stakeholder satisfaction" being most used.
There is also no correlation between the number of demonstrators and Impact Areas and the assessment of the Impact, as shown.



DESIGN IMPACT ASSESSMENT CANVAS

The nine elements shown were identified as assessment of the projects were done.

Conclusion

To assist organizations, teams, and individuals in measuring Design Impact across disciplines and scale, these elements were assembled into a canvas. The Design Impact Assessment Canvas, thus, was realised.

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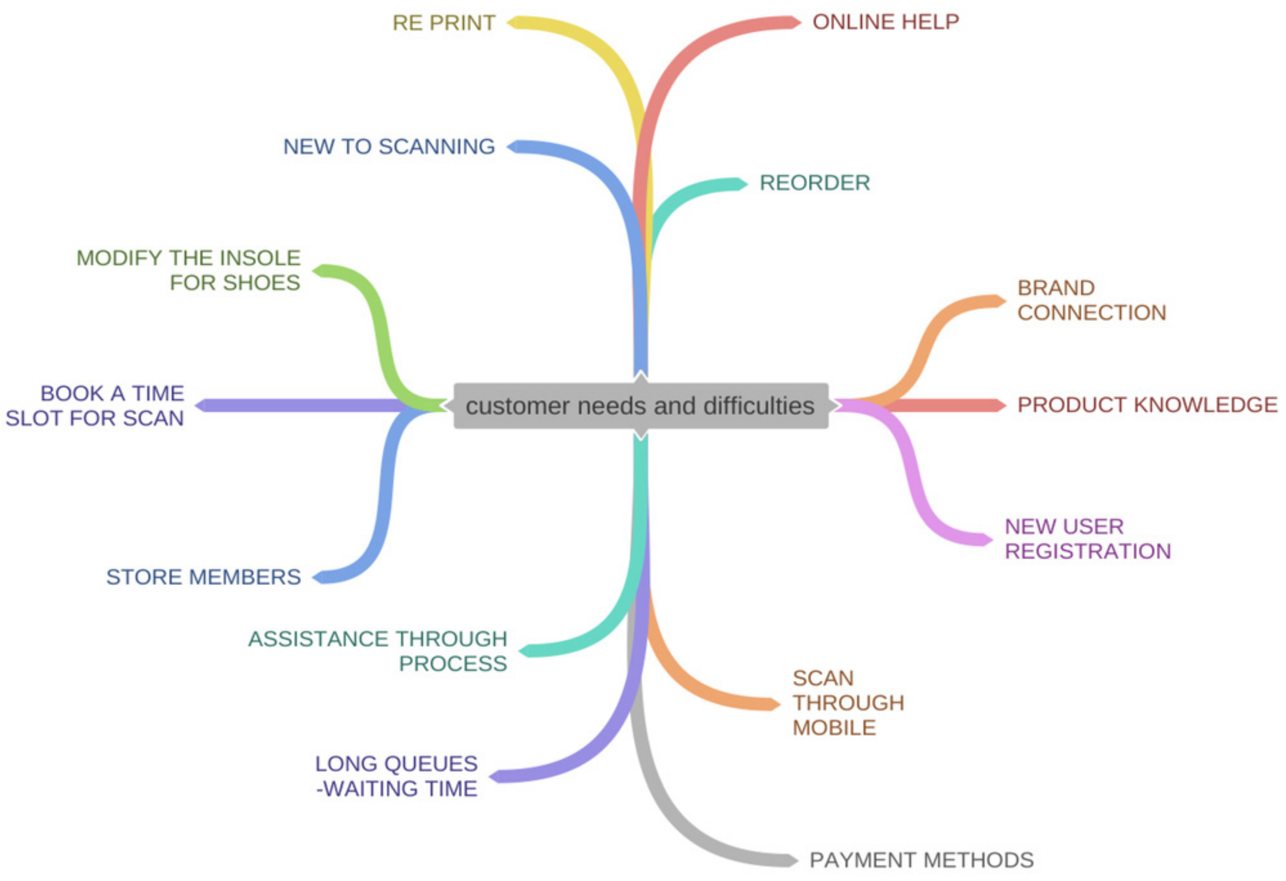
Arlindo silva | Advisor

RESA

RETAIL USER EXPERIENCE

RESA wear is world's foremost foot-care accessory brand, making customized medical grade insoles using 3D printing and foot scanning technologies.
This project is focussed on improving the retail experience in RESA stores, and to ease the customer onboarding experience and assist the customers with their foot scanning process.



EASE THE INITIAL ON-BOARDING PROCESS

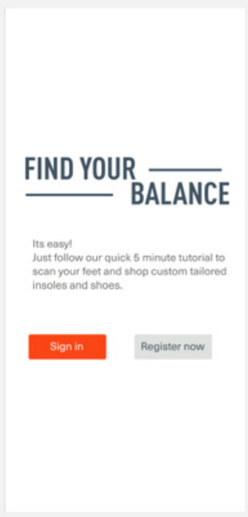
GUIDE CUSTOMERS IN SCANNING PROCESS

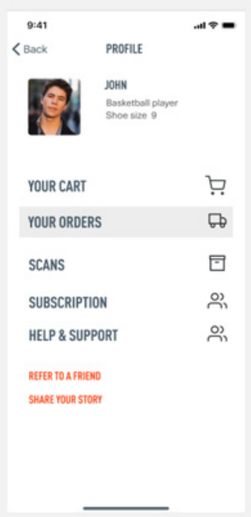
MODIFY AND CUSTOMIZE

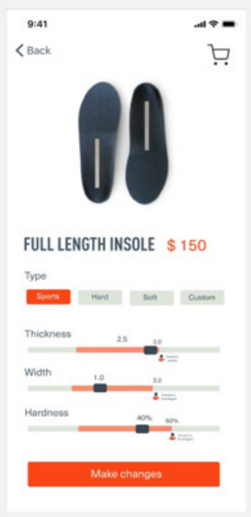
RE-ORDER

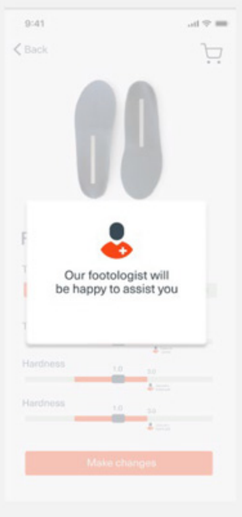
HELP AND ADVISE

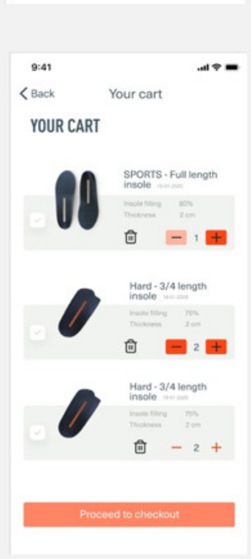
BRAND CONNECTION WITH THE USERS

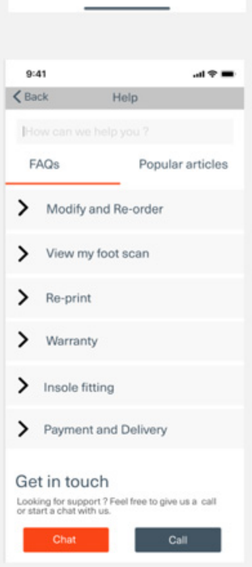


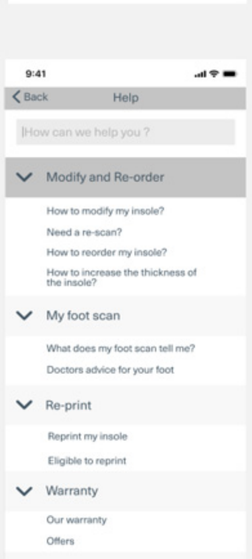


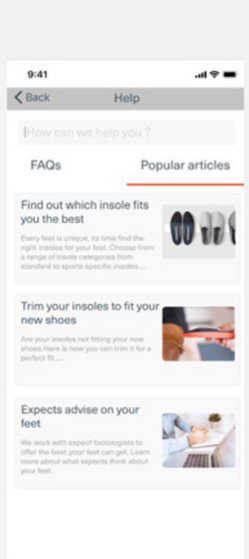


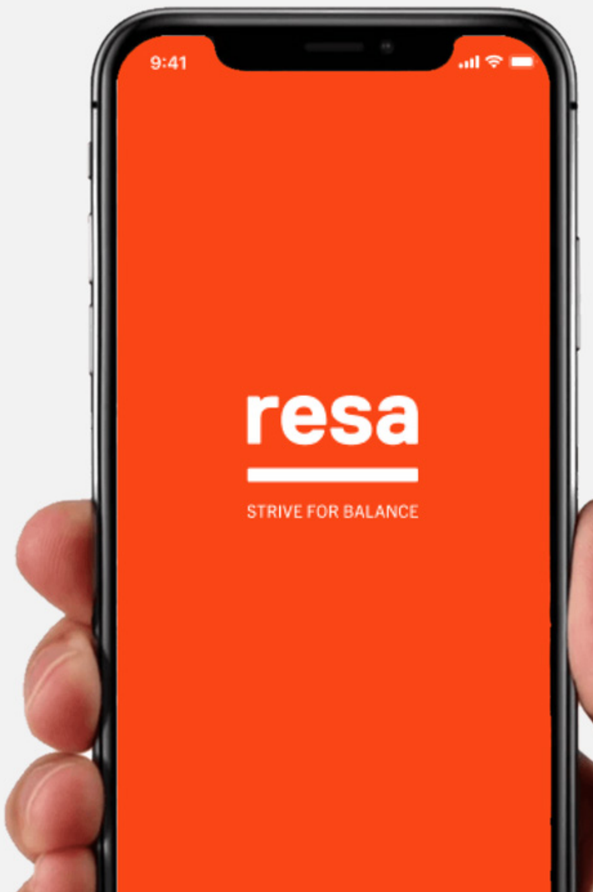












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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Chong Yong Qi (left) | Student
Professor Mohan (right) | Advisor

Project: Robotic, Aircraft Interior Cabin Cleaner

WHAT?

Singapore — Narita

SQ12 flies
SIN (0925) – NRT(1730)

SQ11 flies
NRT (2010) – SIN (1730)

- Taking a typical Singapore Airlines flight, between Singapore and Tokyo
- Shown on the right would be the flight pattern
- Where the same aircraft travels between both locations, almost daily

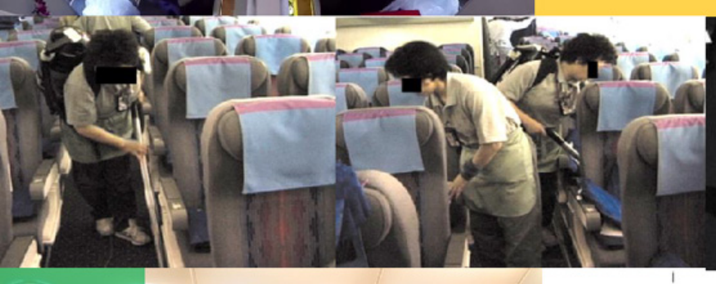
3 forms of cleaning during the different turnaround

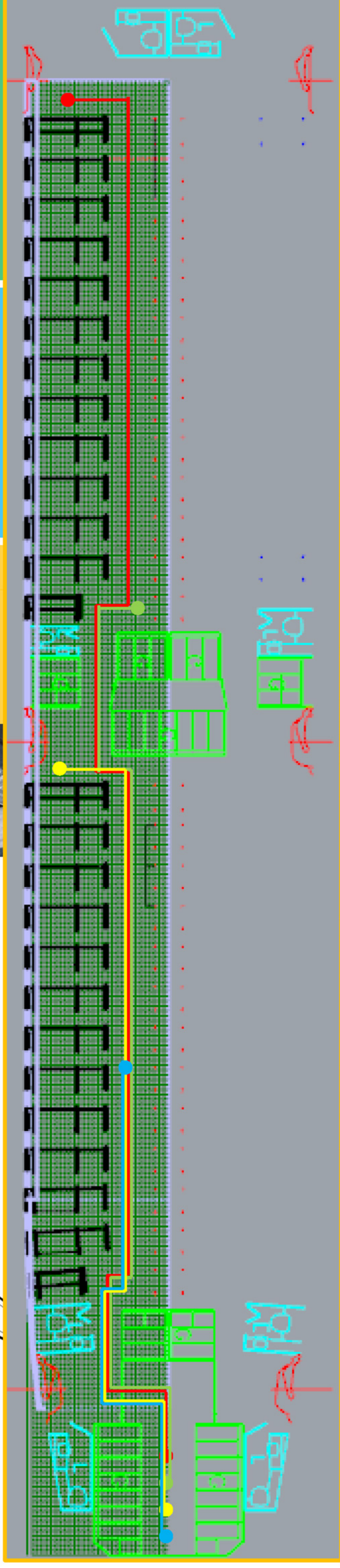
- **Turn cleaning**
  - Aircraft will "turn" and fly again.
  - Generally light cleans
  - Trash removal from the cabin and passenger areas.
- **Overnight cleaning**
  - Aircraft that have flown all their routes for the day
  - Remain overnight, generally between 8 to 10 hours
  - Clean is enhanced with a larger focus on the customer areas in and around seats,
- **Deep cleaning**
  - Seat areas and many surfaces are removed and cleaned to expose the inner workings of the seat, compartments,
  - Cabinets and storage areas.
  - Specialized equipment that helps with a deep clean.

WHY?

Hazards of the job

- Aircraft cabin - space constraints
- Vacuum cleaner has to be carried (¬6kg)
- Aisle width ranges 15" - 18"
- Seat rows ranges 28" – 33"
- Lavatories – 32" – 40"
- Cleaners – constantly in bent and hunched positions
- still difficult to reach certain areas



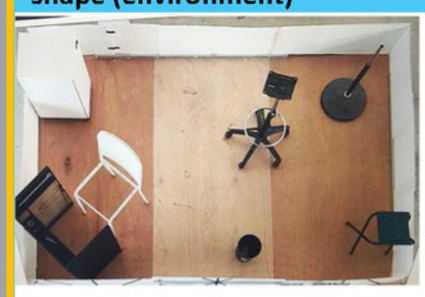
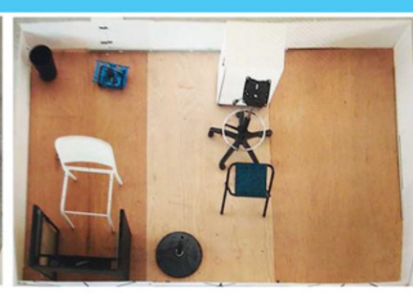
HOW?

- **Under such space constrained condition**
- **A robot to assist with the cleaning might be the solution to such bad working conditions**

1. Intention of this study is to implement a cleaning robot, generated by the "Design by Robot" study. Which allows the robot to fit into as much corners as possible in the aircraft.

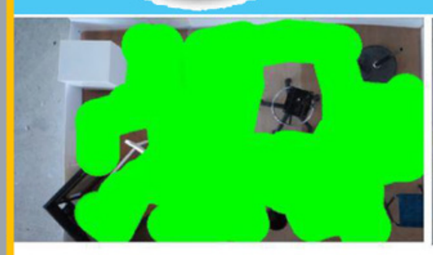
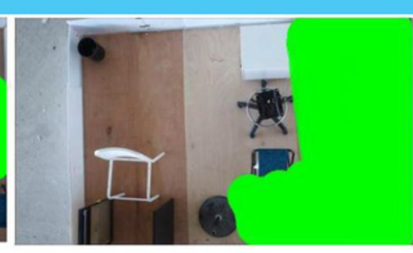
2. And then deploy multiple cleaning robots to do the cleaning of the aircraft cabin. For that the intention is to utilize the "Multiple Traveling Salesman" solution.

Study 1 – Stimulated Study of cleaning with optimized robot shape (environment)

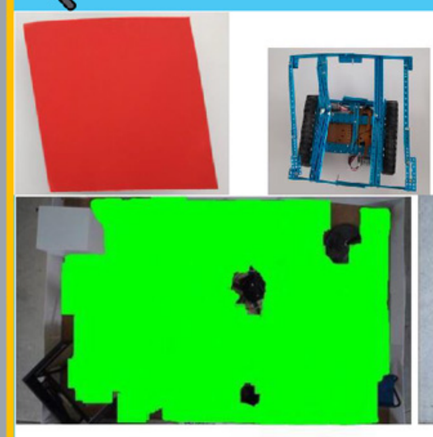
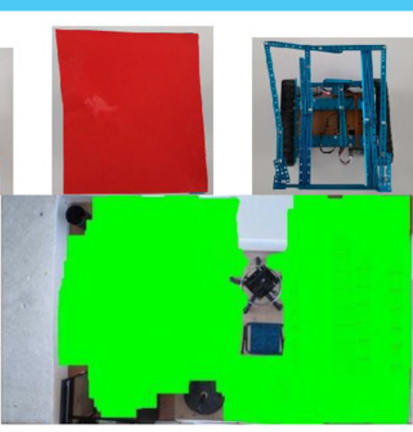
(a) (b)

- General cleaning robot – typically circular
- Circular shapes can only clean so much
- Shown in the coverage area in the pictures below

(a) (b)

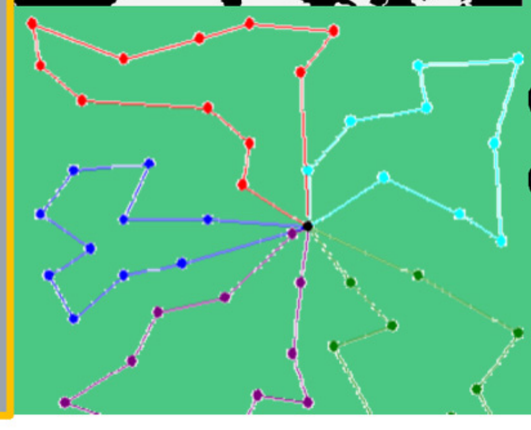
- Generated optimized shapes as shown managed to cover a much larger coverage
- Leaving lesser areas uncleaned
- As opposed to circular shaped designs

(a) (b)

Study 2 – Navigation within the Aircraft Cabin

- Traveling salesman solution
- Optimizes traveling route of journey



- Implement multiple cleaning robots
- Employs multiple traveling salesman solution

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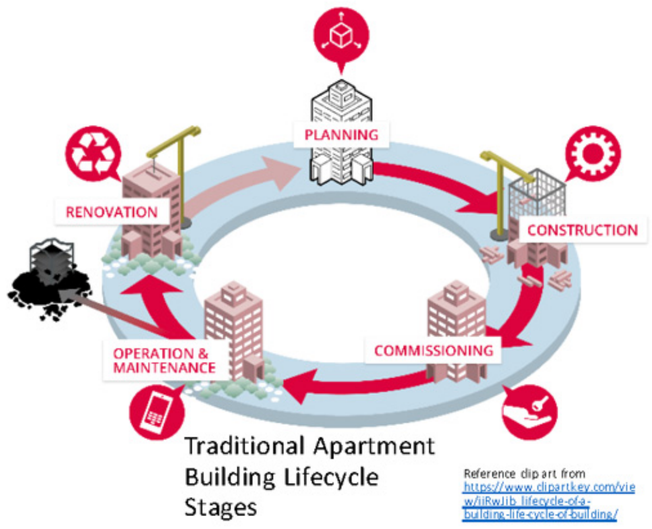
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Chua Hong Zhi | Student
Michael Budig | Advisor

Mass Customized Urban Residential High-Rise Strategy for Social Cohesion

Aim/Purpose : To help Users be involved in the process and realization of their ideal home environment through the collection of data and customization strategies in the realms of community, sharing and personal preferences while keeping it economical.
This design research is applicable as a guide to develop the computational tools and used for generation of urban high-rise type residential developments. The research investigates and explores different types of modeling systems that enable the generation of massing proposals and fomulates and formalizes the requirements needed for these



Traditional Apartment Building Lifecycle Stages

Reference clip art from https://www.clipartkey.com/view/iiRwJib_lifecycle-of-a-building-life-cycle-of-building/

Why - Opportunity

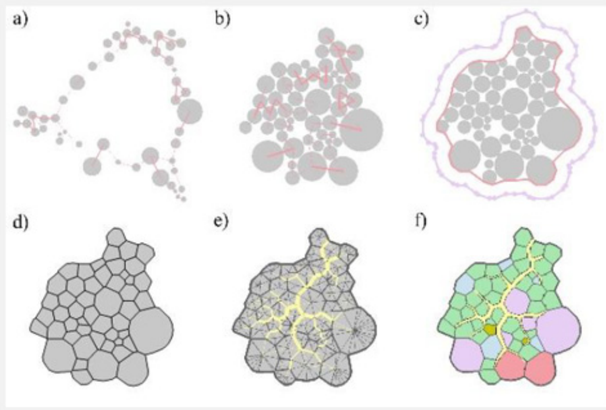
With the development and advancement of computational design and modeling tools. It is possible to do more using current systems and technologies. Current processes of building and apartment design and construction are outdated.
I want to explore the possibilities of customizing each unit in an apartment development for their users/residents.

How – Research and Evaluation

- Finding the properties and parameters in an apartment building development most crucial to the parties involved.
- Analyzing those properties and gathering relevant data from potential end users and owners.
- Testing out different methods of optimization/ generation of solutions. To find the optimal method.
- Gathering feedback from industry professionals and end users to gain insight and further development of system.

Modular Units

Urban Village Project
https://www.urbanvillageproject.com/



Computational Parametric Modelling

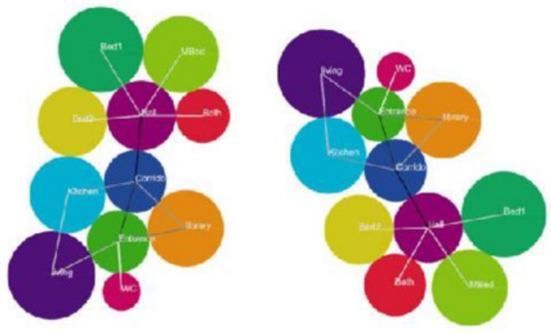
Joel Simon – evolving floorplans
Evolving Floorplans – 2017

AI & GANs Generative Models

Stanislas Chaillou, Harvard Graduate School of Design | Feb 26th, 2019

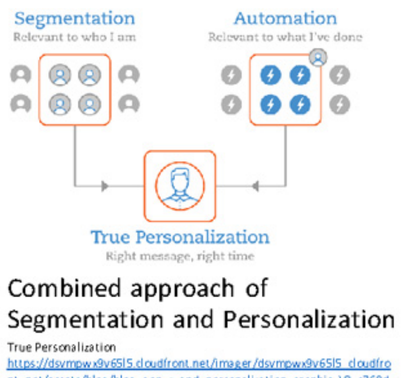
Performance Analysis

Autodesk office
https://autodesk.typepad.com/bimtoolbox/2017/06/generative-design-applied-on-buildings.html



Physics Based Spatial Planning

Physics based spatial planning
https://www.urbanvillageproject.com/



Combined approach of Segmentation and Personalization

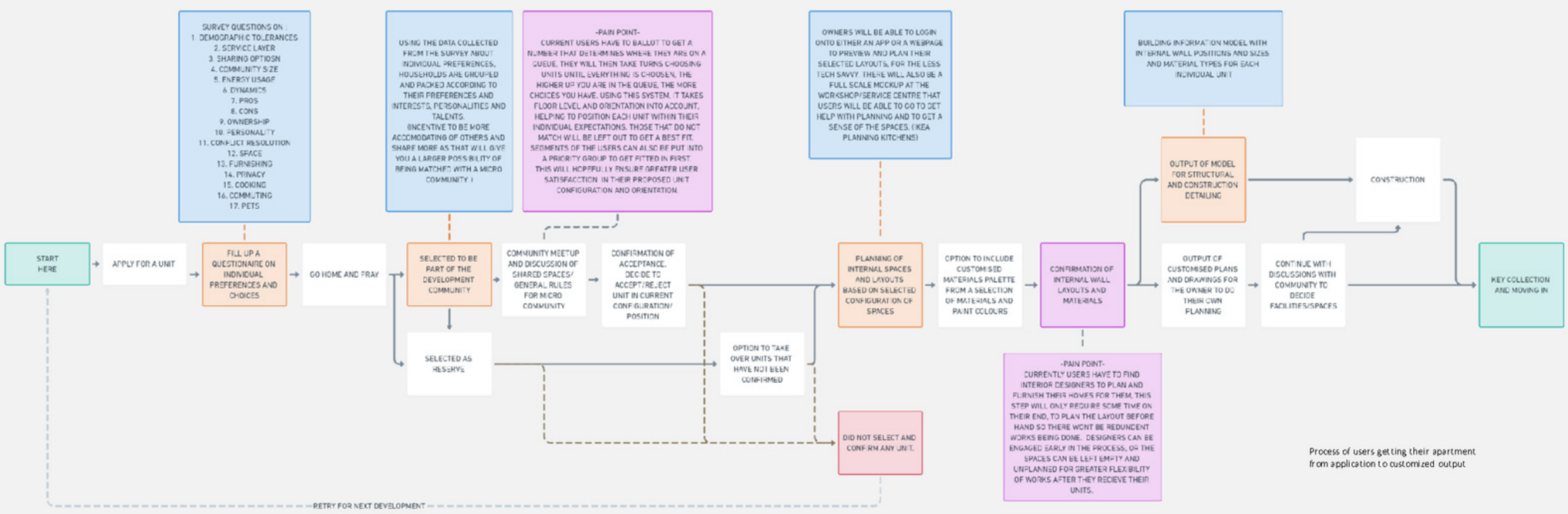
True Personalization
https://dsvmpwx9v65l5.cloudfront.net/imager/dsvmpwx9v65l5_cloudfront_net/assets/blog/blog_gen_z_and_personalization_graphic_V2_c769d5d879c03cf167ff2b93bdd28e8d.png

What – Proposed Solution

- Proposed solution is a system comprising of 4 different Phases.
- First phase will be Data collection, collection of relevant data and information on the users, and the site.
- The second phase analyses the collected information and translates the information into physical and positional data to be input into the computational model.
- The third phase is the generation of the solution/s based on the balanced data from phase 2.
- the fourth phase evaluates the performance of the design based on the initial parameters. Collected data from the evaluation are fed back into the generation of the solution.
- Phases 3 and 4 are repeated until a satisfactory model is achieved.

System Operations –

- 1. In the first step the potential user's data is collected and input together with information of the site and the housing development.
- 2. The second step selection process analyses the collected information and thru a combination of micro segmentation and personalization, includes and groups users into "micro communities".
- 3. After the selection, the third step is the confirmation of the unit that was demarcated for the user. Followed by the planning of the internal spaces with different levels of personalization.
- 4. The fourth step consists of the generation of the complete model packaged together with the relevant data for the engineers and builders to be developed and used for construction planning and prefabrication.



Process of users getting their apartment from application to customized output

The architectural discipline has been experiencing a lot of changes to the way in which its professionals engage in design. The perpetual progression of computing hardware and the significant advancement of Computer Aided Architectural Design (CAAD) has seen Architecture evolve from a practice of principally analogue techniques to one that relies practically exclusively on the digital medium. As a result, the tasks of the architect has seen substantial transformation. Architecture, once a discipline of pencil and paper, now shares creative approaches and applications with Computer Science, Interactive Media, Robotics, and Computer programming. These modern partners provide alternative views and methods of what it is to be a creative professional, questioning the practice of architecture to step beyond the preconceived boundaries and means of operating embodied within conventional practice. Architects can now adapt new approaches for the construction of the built environment.

This research explores developing computational techniques and explores how they can be utilized to augment the way in which urban high-rise developments and buildings may be designed with a focus on highly customized proposals converging around social issues and strategies. This research also adopts the use of a computational design software called Wallacei - an industry developed generative software used to develop and spawn solutions after analysis and scoring. Through an architectural lens, it explores the social aspects of cohesion, developing an understanding for these and how these aspects are converted into different fitness values for the program to optimize solutional generation.

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Project title: Hukaya - Self Home designing platform

Doreen Steven Mlote | Student

Assoc. Prof Bige Tunçer & Assst. Prof. Sudipta Chattopadhyay | Advisors

SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

PROBLEMS

HOW MIGHT WE CREATE A ONE STOP SOLUTION FOR HOME DESIGN?

01 Customers fail to **convey** their ideas of their dream house to architects/engineers and as a result it takes more time and effort to arrive at the customers' desired design.

02 Millions of potential young professionals are unemployed in Africa due to various reasons, mainly nepotism and lack of opportunities.

AIM

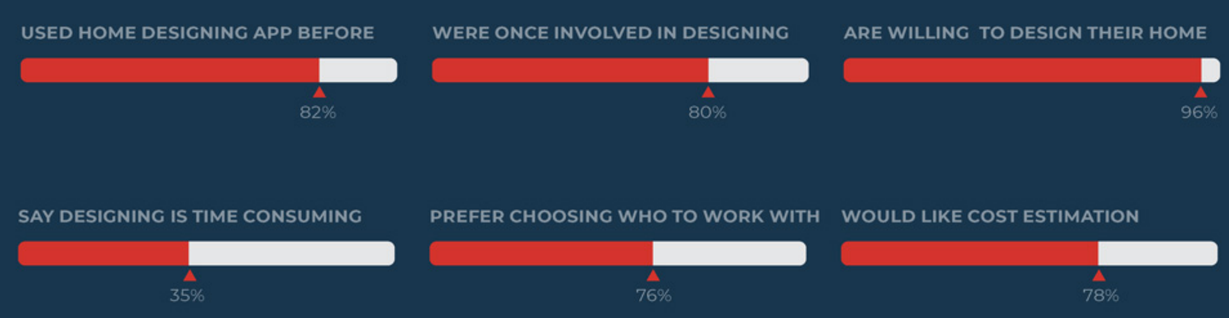
The **AIM** was to simplify the communication between customers and Professionals during design of homes and to reduce the unemployment crisis in the construction sector in Africa.

GOAL

The **GOAL** was to create a platform/tool (in the form of Website) for easy, reliable, convenient and efficient self home-designing.

SURVEY ANALYTICS

PEOPLE WHO..



PRODUCT DETAILS

2D & 3D HOME DESIGNING

Ability to design a home in just few clicks. This includes customisation and specifications to users choices

CONNECT WITH PROFESSIONALS

Ability to Connect with professionnals (Architects & Engineers) directly after designing a home.

DESIGN WITHIN BUDGET & TIME

Ability to prepare financially for the construction of your home

WHAT

STAKEHOLDERS

Registration & Certification boards

Professional users

Investors/Businessmen

Enterprises.

EXPECTED OUTCOME

Home desiging processes will be easier & faster and employment will be created.

IPR CONSTRAINTS

Time: 1 year

Cost: SGD 1000

OPERATION PLAN

USER JOURNEY

DRAW FLOOR PLAN

The user starts by drawing walls and layout.

The user can start from scratch or continue from a pre-existing template

2D

FURNISH & DECORATE

The platform generates a 3D model from the floor plan.

The user can furnish and decorate the interior.

3D

CONFIRM & DOWNLOAD

The user can download the designs and possibly use them as templates.

SAVE

CONNECT

The user can view the list of Architects and Civil Engineers and can select the one with matching interests.

FINISH

TYPES OF USERS

STANDARD USERS

No prior Architectural knowldege

PROFESSIONAL USERS

Architects, Civil Engineers & Interior Designers

ACHIEVEMENTS BY THE END OF REALIZE

2D & 3D DESIGN TOOL

CONNECTING USERS

PROMOTING EMERGING PROFESSIONALS

REDUCED COMPLEXITY

POSSIBLE FUTURE DEVELOPMENTS

COLLABORATIVE DESIGNING

VIRTUAL & AUGMENTED REALITY

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www.hukayahome.com

www.doreenmlote.com

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

< Edith Gracia Sharon Lawrence | Student
Prof Roland Bouffanais | Advisor

PREDICTION OF TURBULENT FLOW BEHAVIOUR USING MACHINE INTELLIGENCE

ABSTRACT

Turbulence is one of the most complex phenomena observed, particularly in the industry. Despite tremendous progress in the field of Computational Fluid Dynamics (CFD) that has given rise to various models and theories that attempt to explain turbulence, they fall short due to various shortcomings in each individual methods.

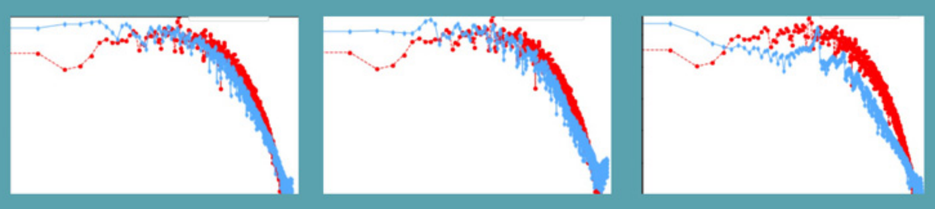
With the advent of Big Data, rapid advances in the field of Machine Learning and rise in the usage of data driven models and learning algorithms, it has now become feasible to develop frameworks of learning models that can be custom-tailored to better understand and resolve turbulence.

The aim of this research is to use advanced neural networks, a machine learning approach, in order to enhance and facilitate the computation of turbulent fluid flows so that it would pave the way in the development of a system that would yield results at acceptable tolerance range, optimal resolutions at low computational cost and time required.

RESULTS

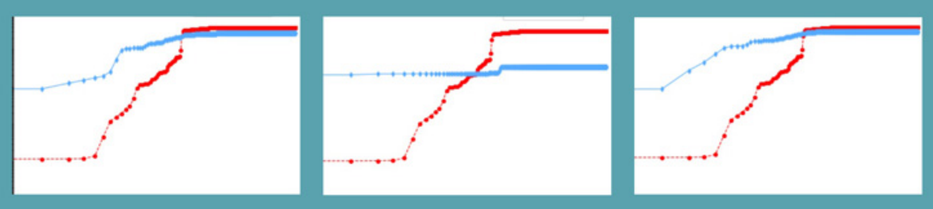
The learning models when executed provide the plot of both the power spectral density and cumulative power spectral density against angular frequency.

The parameter that was varied was the skipsize, with values 30, 40 and 50.



(a) (b) (c)

Power Spectral Density plot at (a) skipsize = 30 (b) skipsize = 40 (c) skipsize = 50

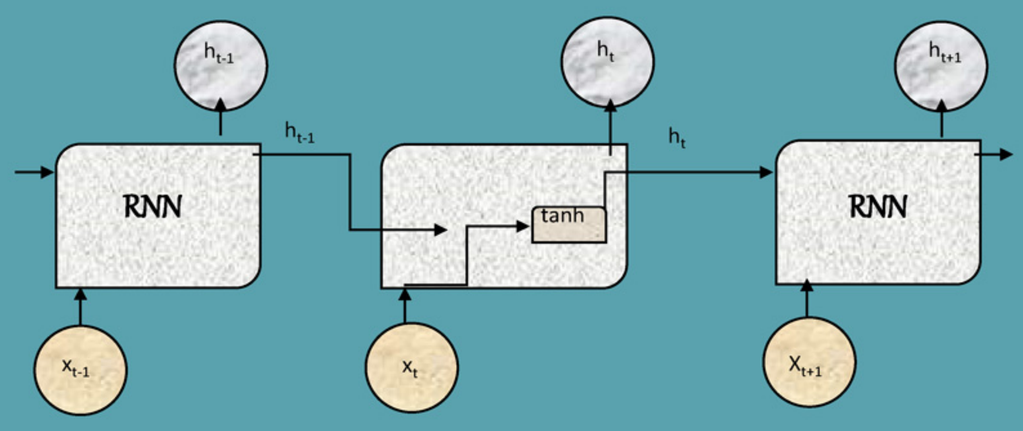


(d) (e) (f)

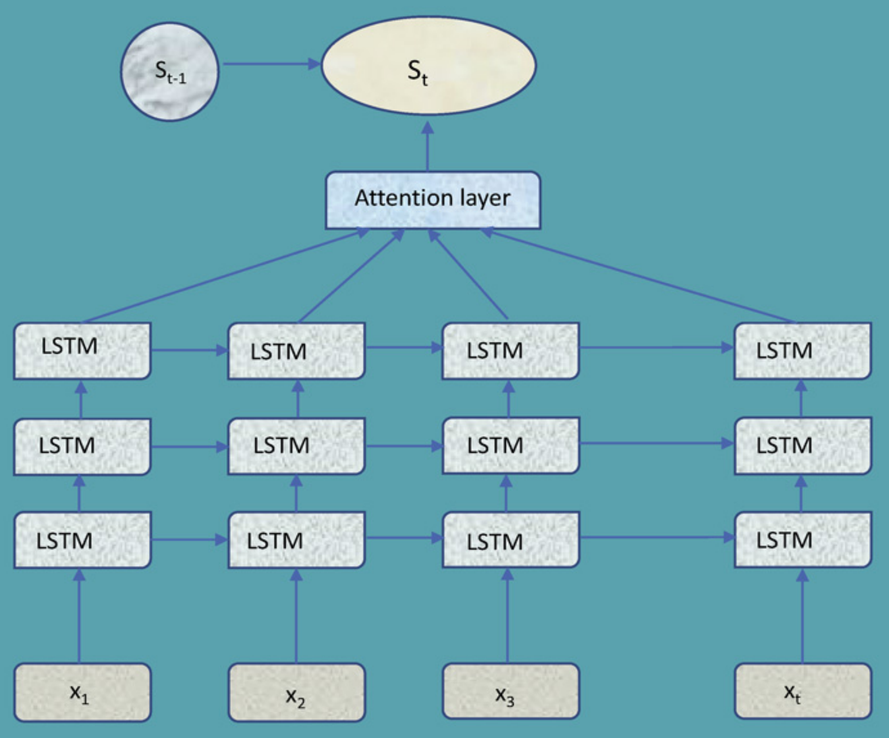
Cumulative Power Spectral Density plot at (d) skipsize = 30 (e) skipsize = 40 (f) skipsize = 50

METHODOLOGY

Recurrent Neural Network is an NN architecture characterized by a feedback loop. This finds application especially in time-series analysis, since the state of the output at a given timestamp t is influenced by the state of the output at previous timestamp t-1.



The LSTM algorithm acts as a gating mechanism that maintains the state of the previous output which helps in proper data transmission. The keras attention layer is used here. The attention layer facilitates the interdependence between the output and the input states and also within the input states.



FUTURE WORKS

The learning model will now be tested by varying other factors such as learning rate, attention layers, etc., to determine the right set of parameters that would ensure that the outputs predicted have the highest level of accuracy possible.

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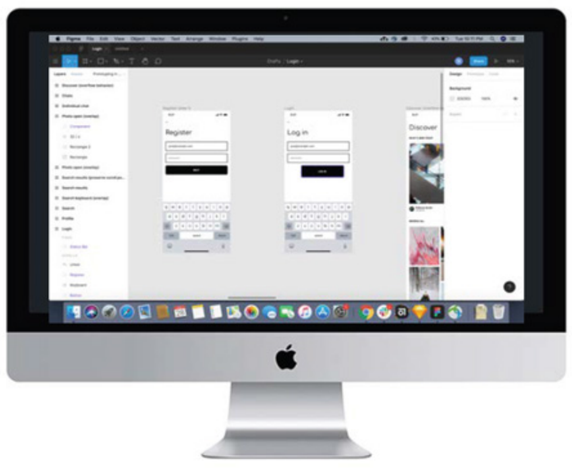
Estefania Yanez | Student
Arlindo Silva | Advisor

A methodology to streamline the design process of digital products by using knowledge-based engineering (KBE)

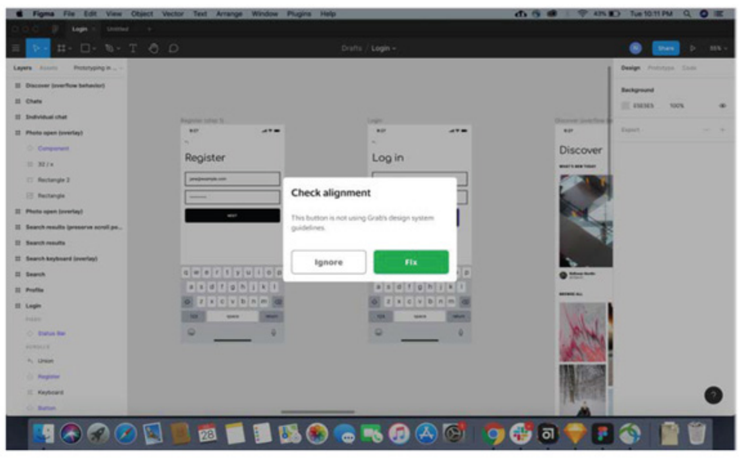
CUSTOMER PROBLEMS



- As a product designer, I would like to get assurance that the concept I am designing during the ideation phase is within the project scope, costs and applies all corporate design guidelines correctly.
- As medium-large company, we would like to reduce the amount of time that product designers spend ideating solutions that are not within the scope defined by the product manager.
- As medium-large company, we would like to reduce the design inconsistencies with the corporate design system.

CUSTOMER PROFILE

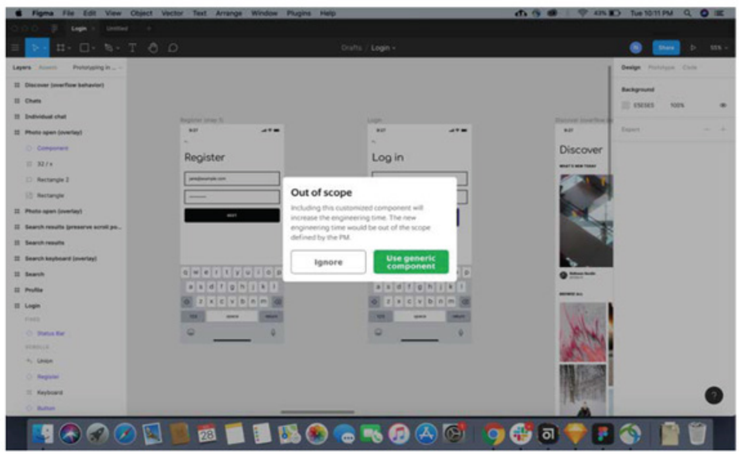
Medium and large tech companies that have a defined corporate design system



USER PROFILE

Product managers and Product Designers of digital services in medium and large tech companies

OBSERVATIONS



- Decisions made by designers during the ideation phase determine the relevant characteristics of a product, having a huge impact on production time and costs.
- In order to make the right decisions at the earliest time, designers need to have access to sufficient and reliable information.

DELIVERABLE

- This research aims to provide a **methodology that compiles valuable internal knowledge** along the product development process (PDP) and use it to help designers to make informed choices within the cost and time boundaries defined by a product manager (PM).

IMPACT METRICS

- Number of times that a design concept is sent back to ideation phase, because PM defines that it is out of scope.
- Amount of time spent by design manager reviewing the correct implementation of corporate design system.

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G R Saravanan | Student
Jian Ying Zhou | Advisor

Background

Industrial work environment is changing. Technology is ever-present in virtually every kind of industry today, dramatic changes of all are taking place in our factories and other industrial environments. Industrial IoT (IIoT): they are used across multiple industries including but not limited to Electricity, Nuclear, water and wastewater, oil and natural gas, transportation, chemical, pharmaceutical, pulp and paper, food and beverage, Smart cities, Smart houses, Pharmaceutical Industries, and discrete manufacturing.

Attacks on Industrial IoT (IIoT) devices, exploiting inherent vulnerabilities, have intensified over the last few years. Recent large-scale attacks, validate concerns about the security of IIoT devices. To find and avoid this kind of attacks, we suggested to create a Honeypot architecture. Honeypots are designed to purposely engage and deceive hackers and identify malicious activities performed over the Internet.

Aim

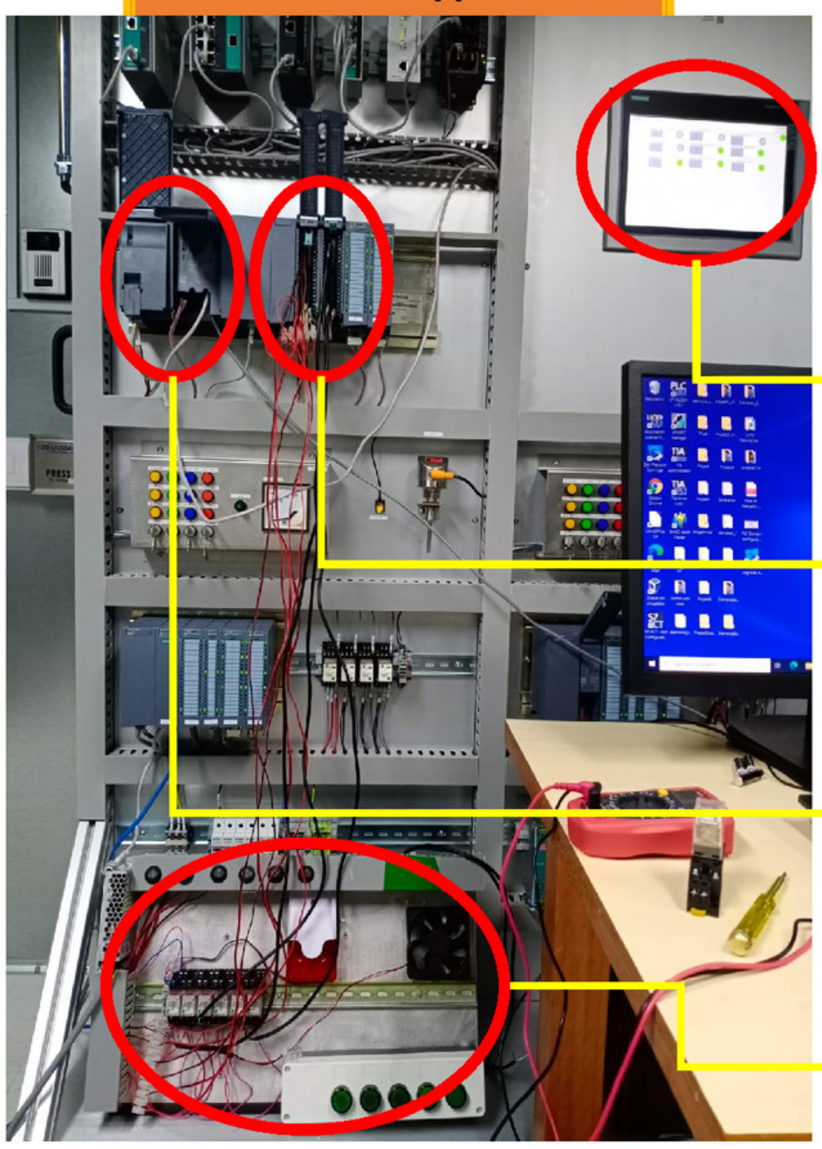
The goal is for those Industrial Automation devices, such as PLC to be discovered and exploited by attacks on the Internet, thereby revealing unknown vulnerabilities. For detection and examination of potentially malicious traffic, we devise two analysis strategies:

- given an outbound connection from honeypot, backtrack into network traffic to detect the corresponding attack command that caused the malicious connection and use it to download malware,
- perform live detection of unseen URLs from HTTP requests using adaptive clustering. We show that our implementation and analysis strategies can detect recent large-scale attacks targeting Industrial Internet of Things (IIoT) devices with overall low cost and maintenance effort.

Focus

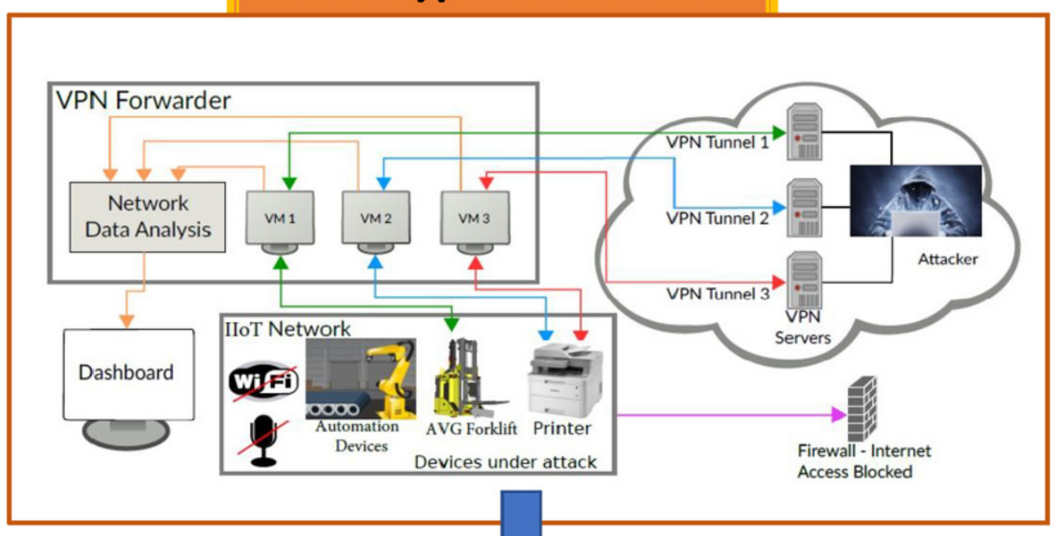
- Find a most vulnerable Industrial Automation devices such as PLC and design an industrial Automation architecture (Physical or Stimulated) and connect with this Honeypot architecture to detect the Industrial attacks.
- Design of a honeypot framework that incorporates Industrial Internet of Things (IIoT) devices for high interaction, utilizing low-cost commercial VPN providers
- An implementation of the proposed framework, demonstrating an automated, scalable, and economical approach to integrate IIoT devices
- Two live traffic analysis methods to detect large-scale attacks and subsequently 0-day vulnerabilities in IIoT devices using our honeypot infrastructure

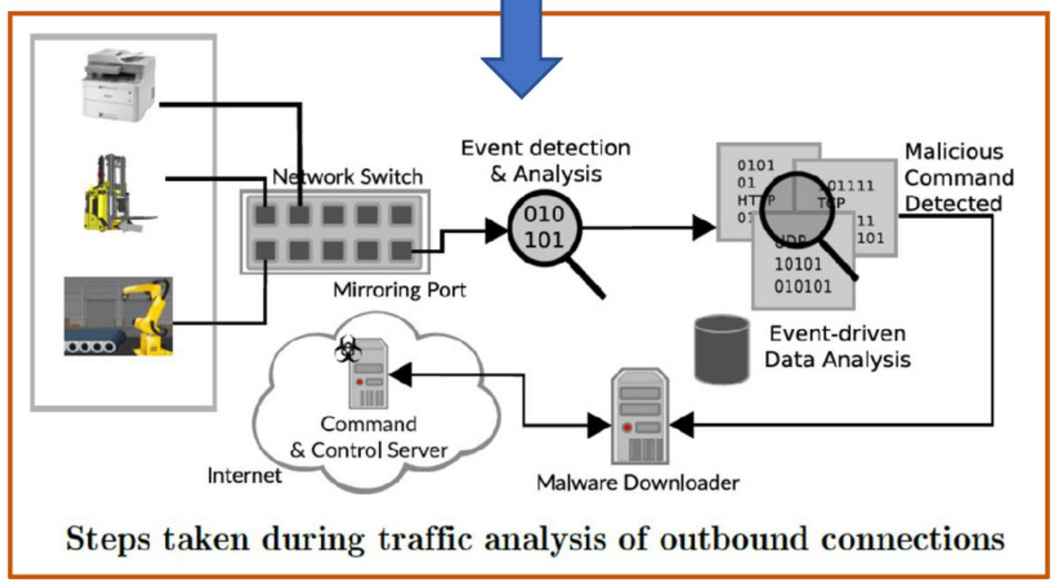
Prototype



- Smart Home Prototype is completed and controlled by PLC through HMI. Finally the Prototype is connected with Honeypot through PLC port.
- HMI Programming Completed, Necessary buttons are created to ON/OFF the devices.
- Input & Output Module Connected with Prototype through Switches & Relays.
- PLC & HMI Programming synchronized with workstation TIA portal.
- PLC Port connected with Honeypot and exposed for attackers.
- Prototype devices are synchronized with the PLC Input & Output module.

Honeypot Network





Steps taken during traffic analysis of outbound connections

IPR Conclusion

Ideate - Discovered the topic and proposed potentially innovative ideas about Industrial Automation device to connect with Honeypot for Intrusion detection, through literature reviews, benchmarking, ideation techniques, design of the architecture, on how to integrate the Automation device to the IoT honeypot framework.

Prototype - Developed Smart Home Prototype using Highly Vulnerable Automation Device (such as Siemens PLC) and connected with Honeypot Network.

Realize - Concluded the study about "Detect the attacks to Industrial Automation device" with some proof-of-concept of the ideas developed and prototyped. Helps uncovering vulnerabilities and driving innovation in developing defensive tools and frameworks. All this study and experiment will be used to prepare my thesis.

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GOH JUN RUI | Student

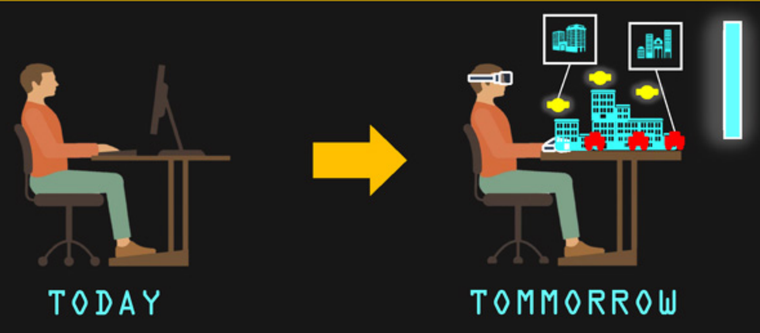
Asst. Prof U-Xuan Tan | Advisor

VIRTUAL REALITY ROBOTIC COMMAND & CONTROL SYSTEM

DSO

There is an increasing demand for robotic platforms to replace manpower due to aging population and declining birth rates. Humans control multiple robots through a Robotic Command and Control (RC2) System. As the number of robots increase, controlling the robots becomes harder and more complicated.

AIM & GOAL



AIM My aim is to enhance RC2 operator's performance

GOAL My goal is to enhance operator's performance through interaction design using Virtual Reality technology

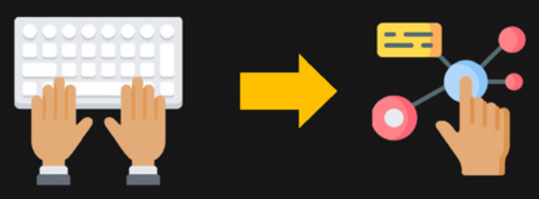
RESEARCH QUESTIONS & HYPOTHESES

RQ1 Does 3D representations of spatial information improve clarity of the information?

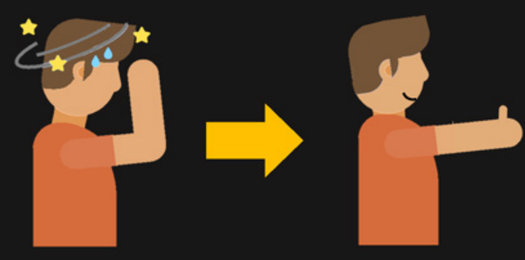
H1 Spatial information represented in 3D space will improve C2 Operator's situation awareness.

RQ2 Does 3D gesture inputs improve control of the RC2 system?

H2 3D gesture inputs will improve operator's level of control for spatial tasks.



RQ3 How can we minimise cybersickness?



METHODOLOGY & APPROACH

Research Clarification
- Use-cases Research
- Concept of Operation
- User Interview
- Designer Interview

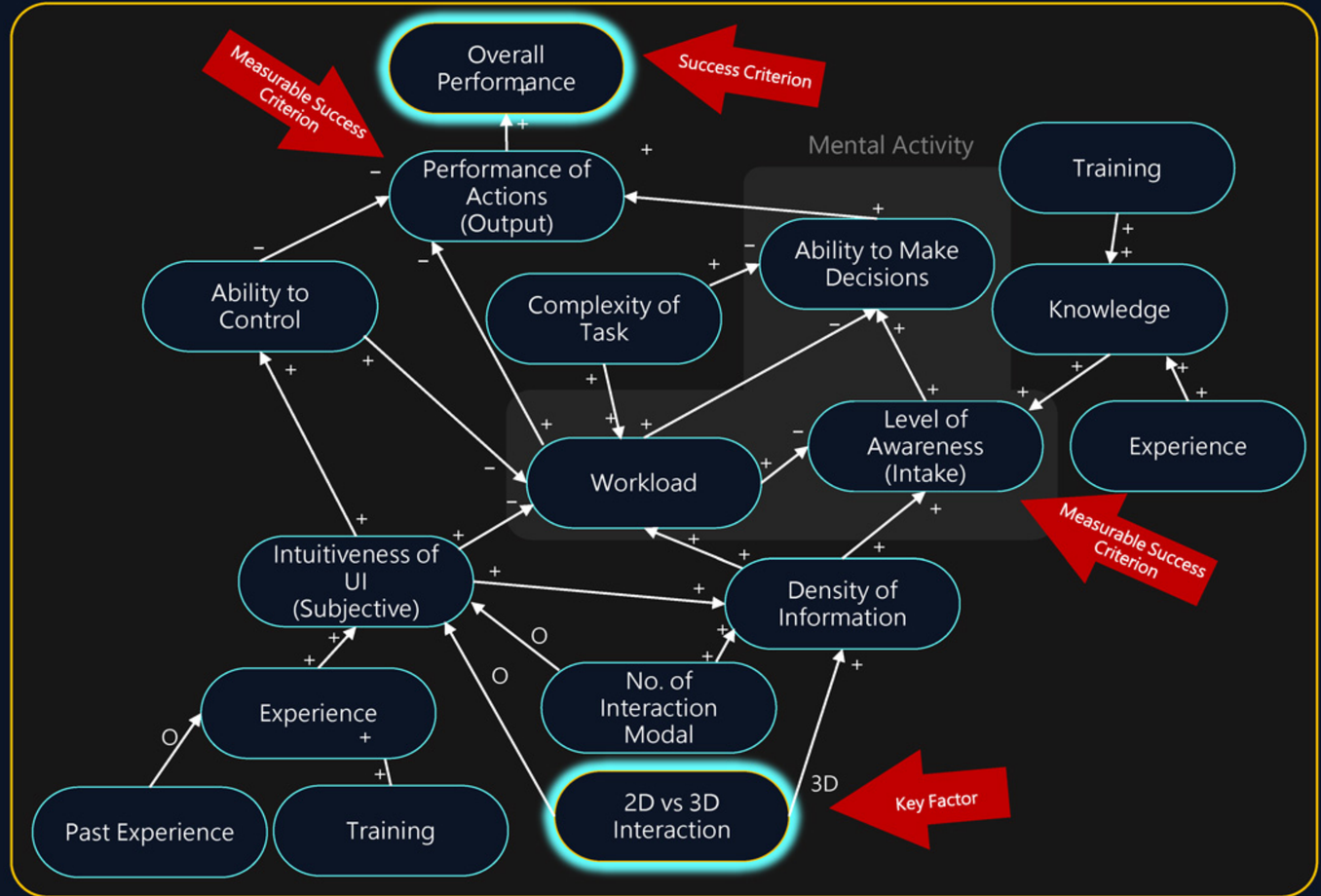
Descriptive Study 1

Literature Review on
- Interaction Design
- Game Design
- Performance Measurement

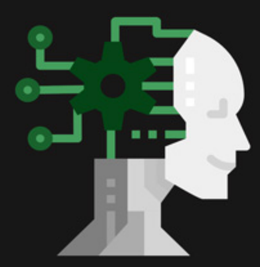
Prescriptive Study
- Conceptualisation
- System Design
- Experiment Planning

Descriptive Study 2
- VR Game Experiment
- Interview
- Score and Data Analysis
- Qualitative and Quantitative Assessment

REFERENCE MODEL



CONTRIBUTION & EXPECTED RESULT



Contribution towards Human-Computer-Interface (HCI) Design and C2 UI Design.

Identify areas to enhance C2 operator's performance in C2 design .

As a Prove of Concept.

Singapore University of Technology and Design (SUTD)
MSc Innovation by Design
Advisor: Asst. Prof U-Xuan TAN

Jun Rui GOH
HP: 94780038
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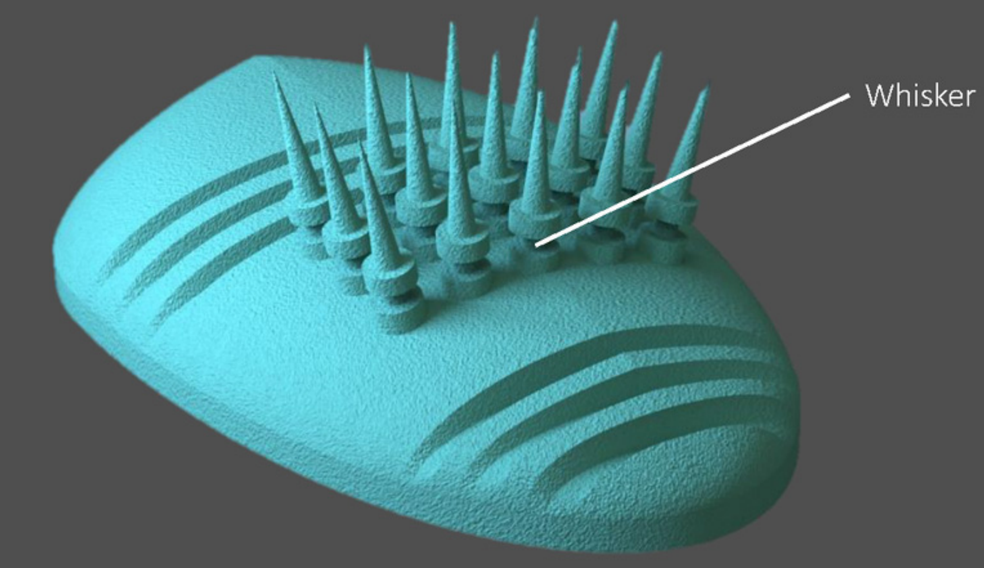
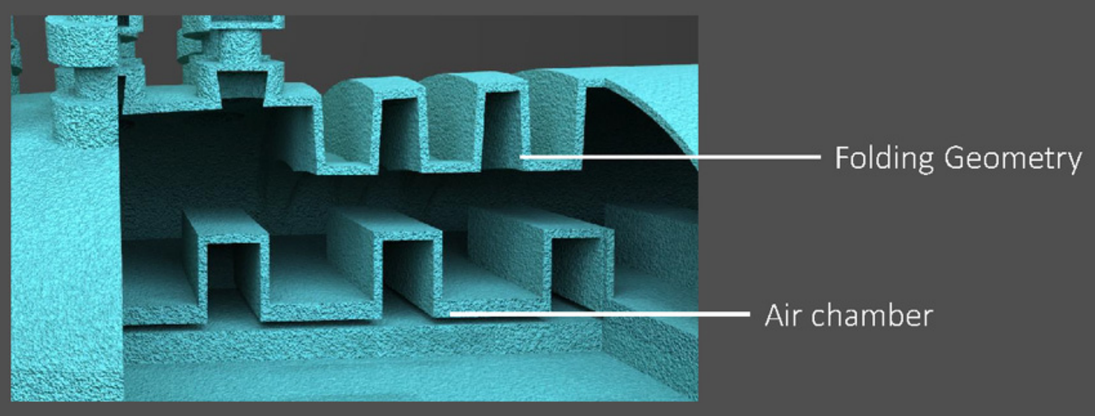
< Gumawang Hiramandala > | Student
< Prof Pablo Valdivia > | Advisor

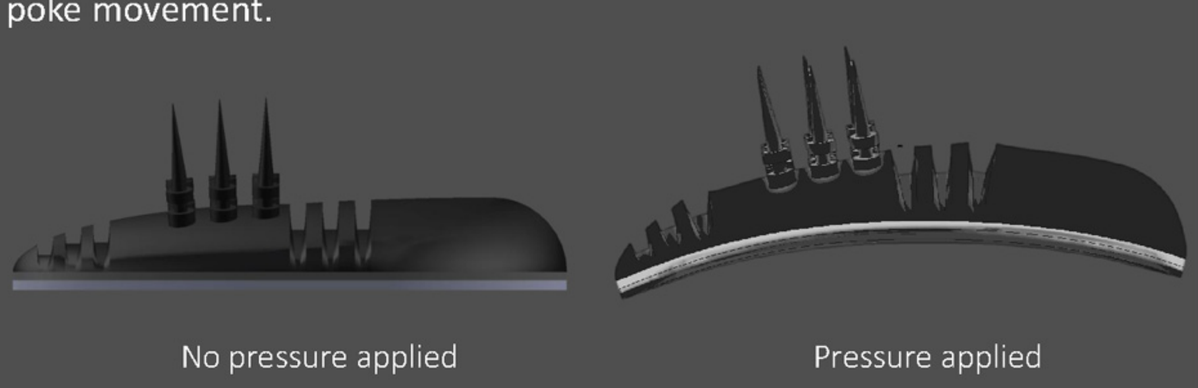
What

Soft robot inspired by hedgehog with intentions to aid in relaxation through the use of acupuncture.



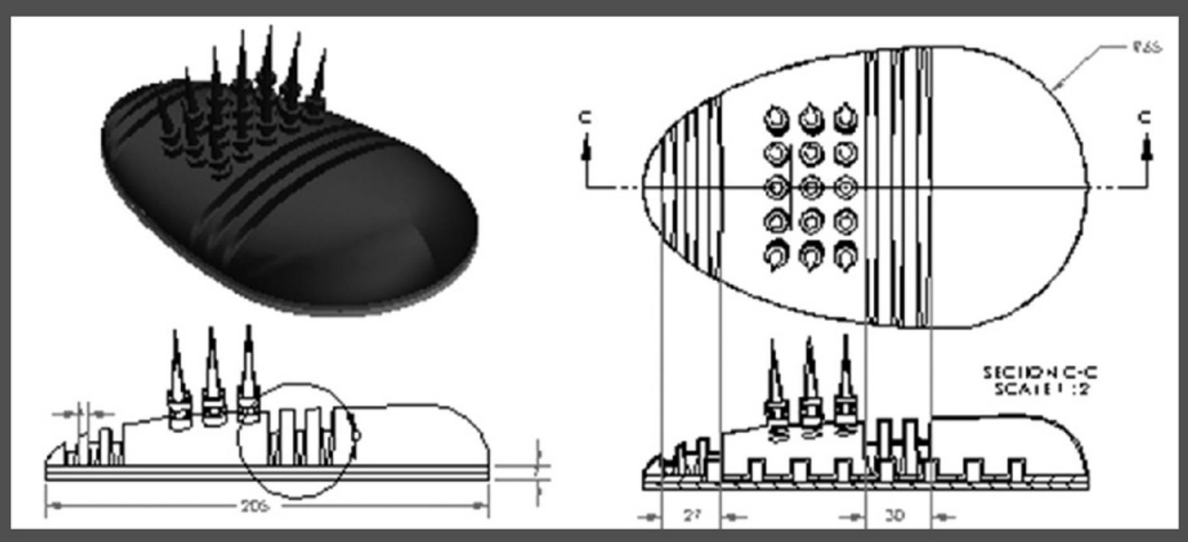


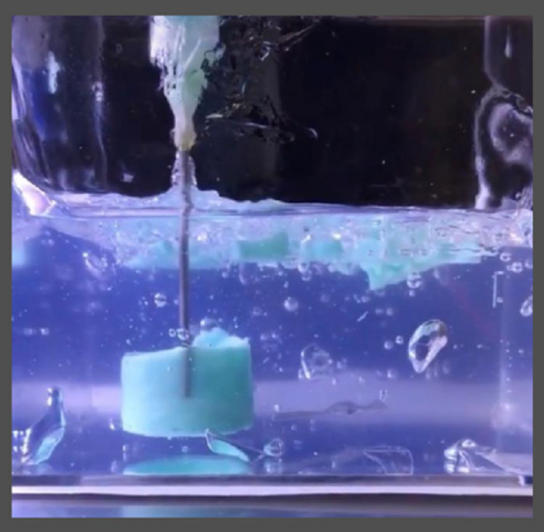
When an air is supplied in the air chamber , air gets trap inside the chamber , allowing for the the air chamber to expand which eventually allowing the soft body to bend , thus moving the whisker to create a poke movement.



No pressure applied | Pressure applied

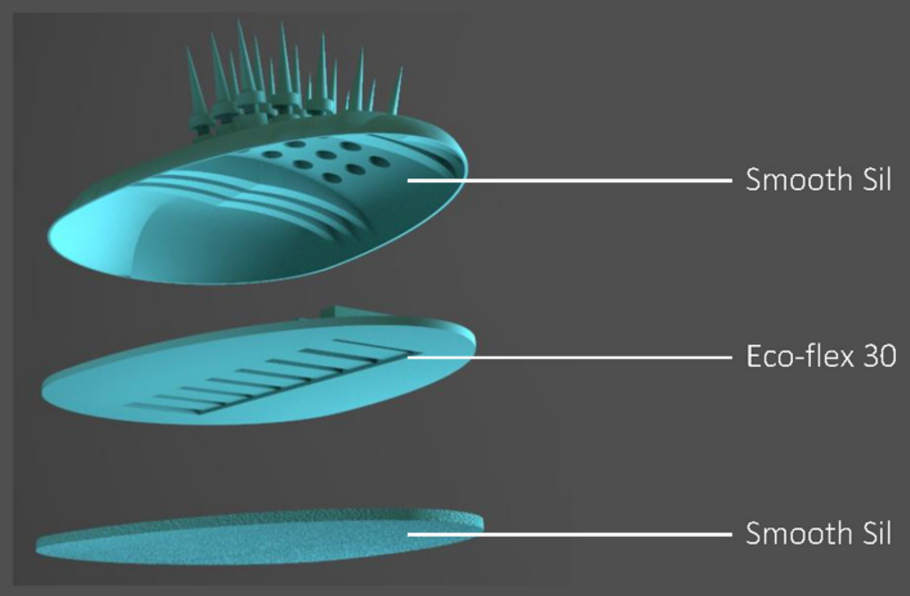
Method of production and material





The robots uses 2 different material such as Eco-flex 30 and Smoothsil which are printed in hydrogel support bath.

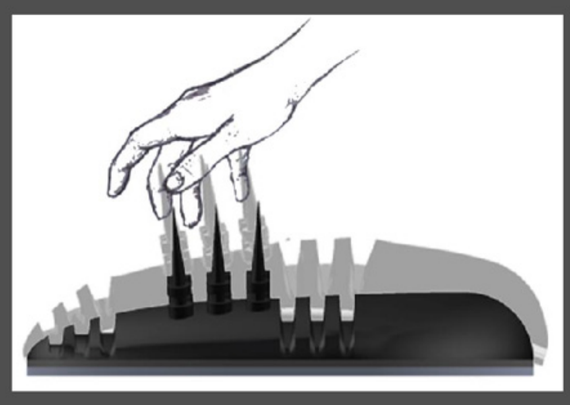
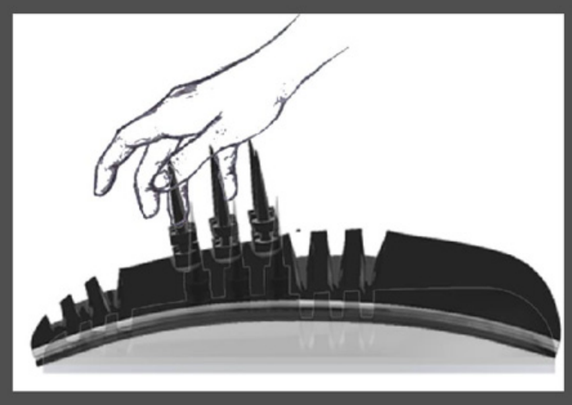
Depending on the speed of the print , the “thickness” of the material will change.



The parts are then combined with one another with epoxy glue , with the eco-flex 30 being sandwiched in between the parts.

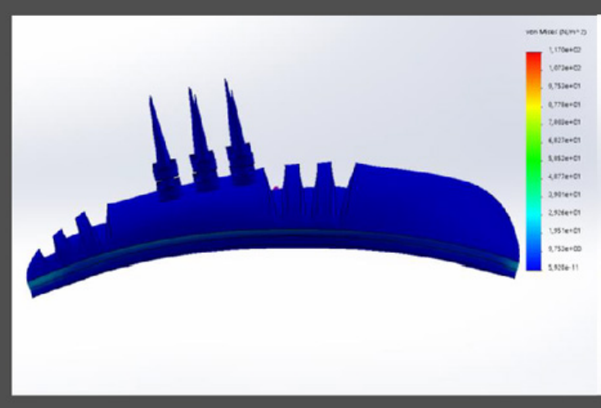
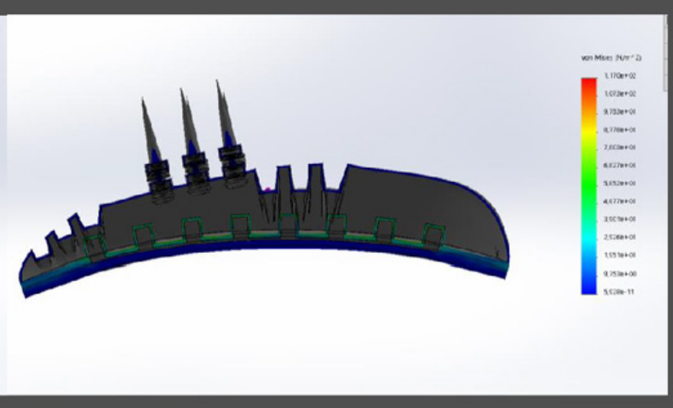
Why

The idea is to have a soft robot that is inspired by a hedgehog and by combining the special feauture of hedgehog spikes , acupuncture and massage, user would be able to relax themselves simply just by having their palm being poke or having their palm stroke by the robot.

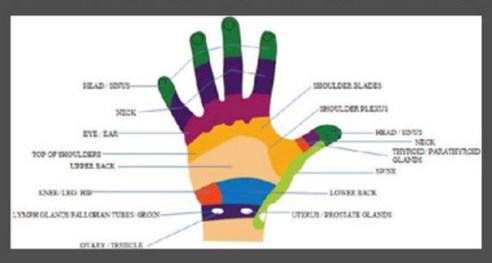



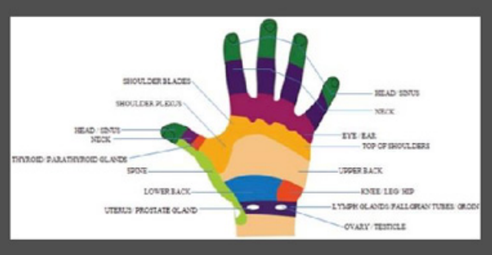
How

By combining two different material that have different rigidity , it will allow the body to have movement that mimics the curl movement of a hedgehog .

User will have their hand palm to be poke at specific area. When having this area of the palm poke , it will cause a reaction for the users to relax and de-stress themselves.





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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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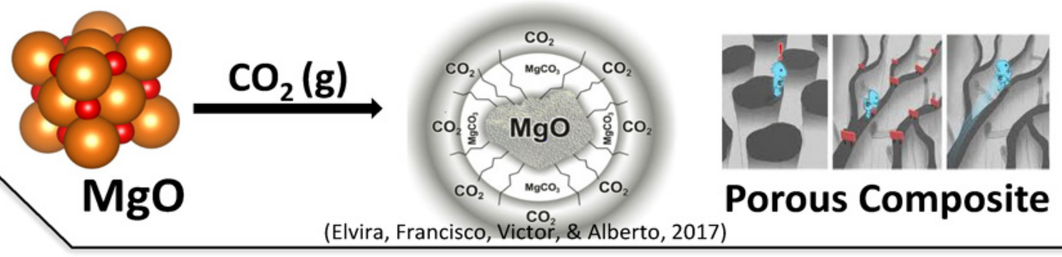
Assoc. Professor Wu Ping | Advisor

Electrospun Nanocomposites for Room Temperature CO_2 Capture

Entropic Interface Research Group | Engineering Product Development Pillar
Singapore University of Technology and Design
Email: hasanthi_Senevirathna@mymail.sutd.edu.sg

Background

- ✓ There is growing concern that anthropogenic carbon dioxide (CO_2) are contributing to global climate change.
- ✓ MgO-based absorbents have been recognized as a promising CO_2 absorbent at intermediate temperature since Magnesium Oxide (MgO) chemically reacts with CO_2 to form thermally stable Magnesium Carbonate.
- ✓ Though MgO shows a high theoretical CO_2 capture capacity, the reported CO_2 uptake of commercial bulk MgO could be low as a result of the limited base sites.



(Elvira, Francisco, Victor, & Alberto, 2017)

Aim and Goal

- ✓ **Aim:**

To capture carbon dioxide in the atmosphere at room temperature (RT) by adsorption using solid adsorbents.

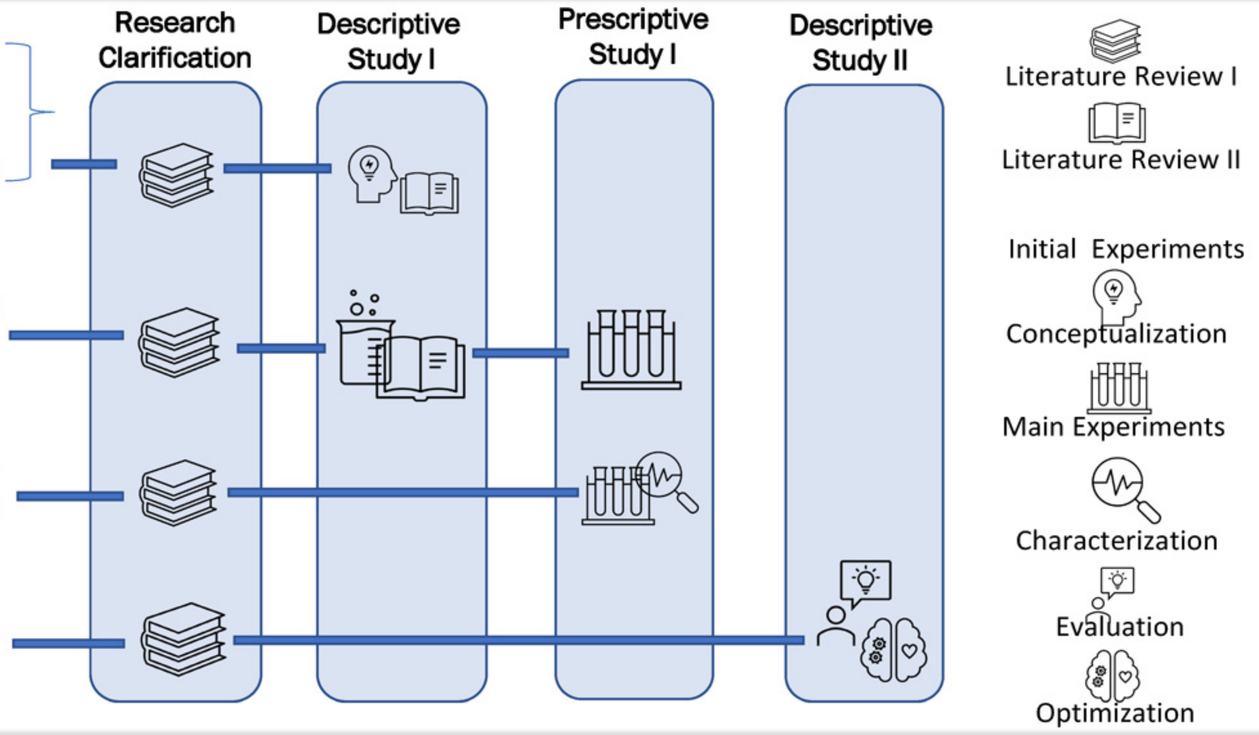
- ✓ **Goal:**

To develop a novel and a sustainable nano material which capable of adsorbing inhouse CO_2 in the atmosphere at RT & apply the developed material in inhouse CO_2 sensor.

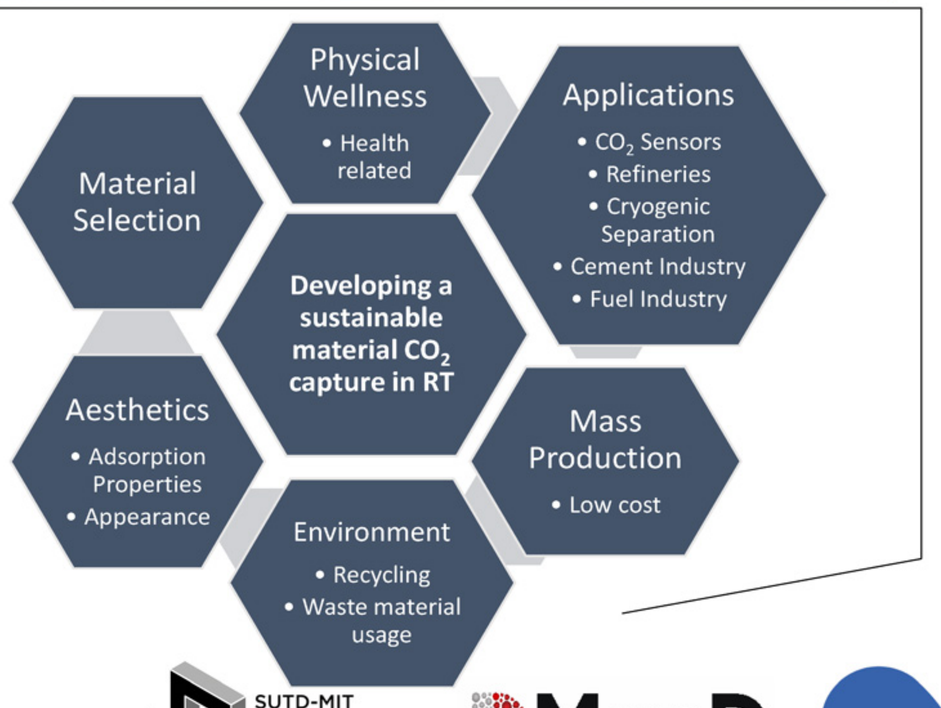
Project Questions

1. What are the researched materials/commercially available materials for CO_2 adsorption in room temperature.
2. In what ways the different CO_2 adsorption mechanisms affect to the capture capacity of a material.
3. What are the constrains in current commercial CO_2 adsorbent materials when using them in inhouse CO_2 Sensors and their properties.
4. Is it possible to use the waste product of desalination, the bittern as a raw material in developing CO_2 capture materials and the effect the CO_2 capture capacity.
5. How does the CO_2 capture capacity of a material use in real-life applications in RT.

Project Approach

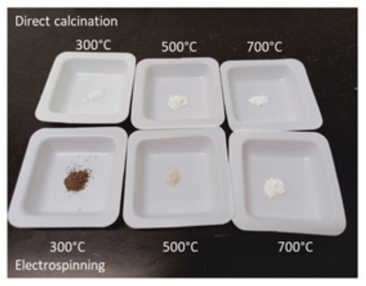


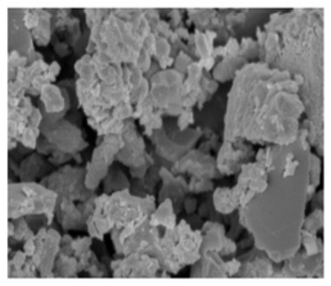
Areas of Contribution



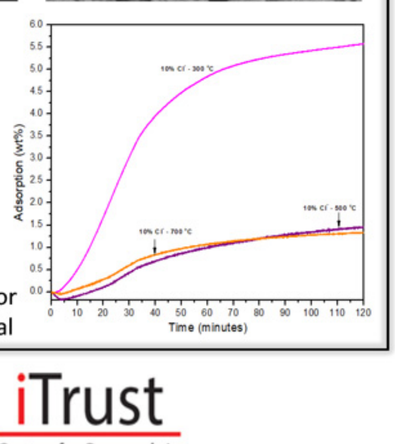
Project Deliverables

- ✓ A novel composite material based on MgO which highly cost effective and high adsorption rate at RT as it is vital when it comes to mass production incorporated with inhouse CO_2 sensors.
- ✓ Ability of using desalination waste material as a raw material to develop the composite.
- ✓ Apart from that this material can also be modified to include in applications





Example of a design of a CO_2 sensor with developed composite material



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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

HIMAJA VECHALAPU | Student
Assis . Prof. JIANG WENCHAO | Advisor

Human-Object Interaction with passive RFID Tag

PROBLEM STATEMENT

How might we enhance the low-cost common RFID Tag with sensing ability, such that they can detect human interaction as well as sensing the environment around the them ?

AIM & OBJECTIVE

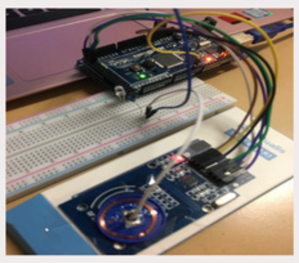
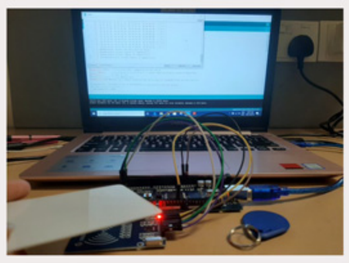
- To enhance the day- to-day human interactions through RFID tag or cards with ubiquitous components at low cost.
- To design the tag with efficient data protection.

IDEATE

- How might we facilitate the human object interaction with passive RFID Tag at low Cost and high security?
- What are some learning tools needed to train a model to achieve better detection performance, In-order to collect and process the sensing data ?

PROTOTYPE

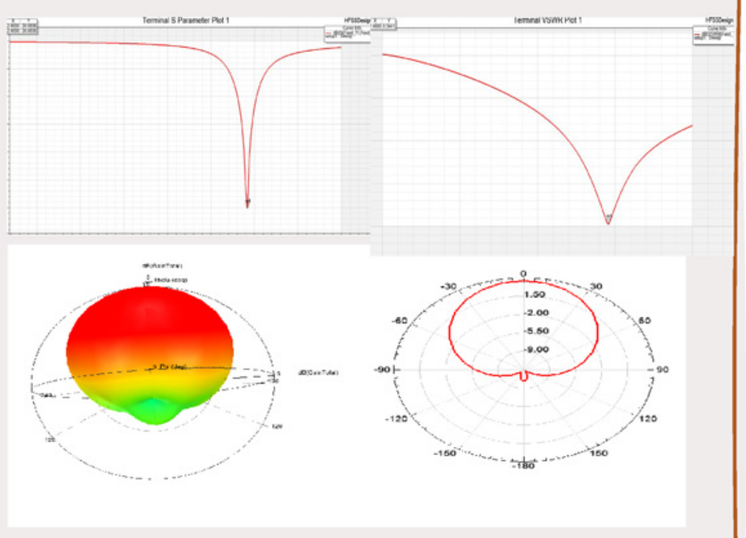
- Initially the tag has been tested by using Arduino software, on Arduino Mega 2560 board and Reader RC 522.

CHALLENGES:
Designing the layout of RFID tags carefully such that it doesn't interfere with each other when read by the reader.

REALIZE

In the Realized phase the tag has been mostly simulated virtually in order improve the efficiency in all aspects.



The above figures reveal some of the initial radiation, gain, VSWR, S - Parameter of the antenna designed virtually.

FUTURE WORK

In future the development of the RFID tag is going to be simulated at optimal frequency range in order to increase the efficiency of its working to detect human object interaction.

CONCLUSION

The developed RFID tag can track human interactions and revamp their everyday life with efficiently protecting their data.

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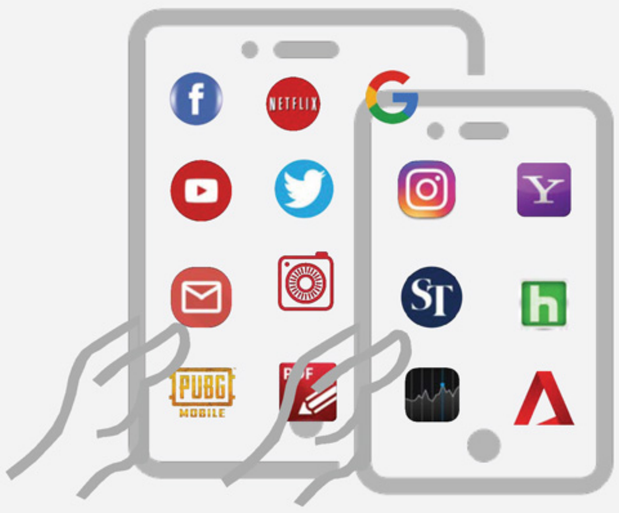
Prof. Arlindo Silva | Advisor

NECK PAIN – PREVENTION & PRECAUTION

Problem



Vision problem

Thumb arthritis

Sleep disorder

Cubital tunnel syndrome

Neck pain

.... more

Neck pain is getting very common in recent days. Study shows that the pain and progressive medical conditions in the cervical spine can be mostly attributed to poor ergonomics of using mobile devices like tablets and smartphones for a prolonged period.

Research

Global Burden of Disease on leading cause of **Disability-Adjusted Life Years** (DALYs) **(Low back & Neck pain)**

Epidemiology → Middle-age group is higher than aged people

Smartphone usage in Singapore:
95% of commuters in trains
40% of commuters in buses
Posture: Poor posture

← **Ethnography**

References

1. Hurwitz, E.L., et al., *The Global Spine Care Initiative: a **summary of the global burden of low back and neck pain** studies.* European Spine Journal, 2018. 27(6): p. 796-801.
2. Praveen, J.J., T.J. Lim, and A. O'Brien, ***Neck Pain in Changi General Hospital**: An Observational Study.* Proceedings of Singapore Healthcare, 2014. 23(3): p. 209-217.
3. Naeem, Z. (2015). "**Health risks associated with mobile phones use**." International journal of health sciences 8(4).
4. Penning, L., ***Normal movements of the cervical spine.*** American Journal of Roentgenology, 1978. 130(2): p. 317-326.
5. Strimpakos, N., ***The assessment of the cervical spine.** Part 1: Range of motion and proprioception.* Journal of bodywork and movement therapies, 2011. 15(1): p. 114-124.
6. Przybyla, A.S., et al.**, *Strength of the cervical spine in compression and bending*.** Spine, 2007. 32(15): p. 1612-1620.

Ideate

Literature Study

Scientific Analysis

Market Analysis

Customer Needs

Gap Identification

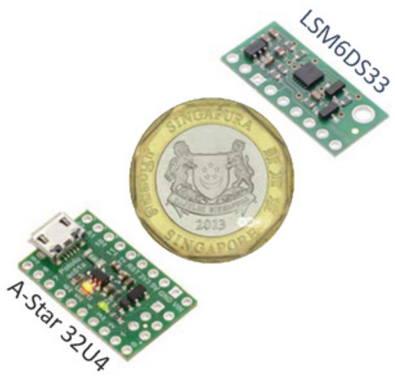
Concept Generation

Technology Analysis

Product specification

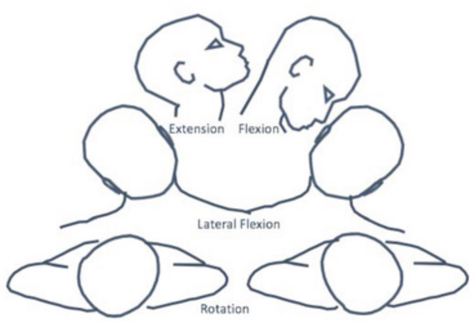
Experiment Planning

Prototype

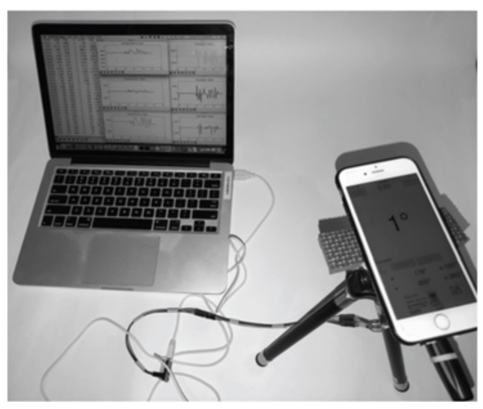


Components

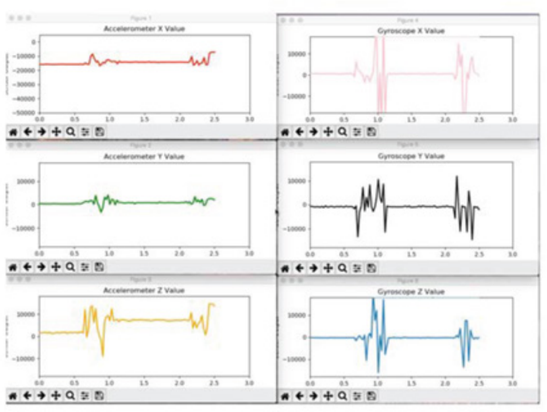
Neck motion simulation setup



Neck range of motion

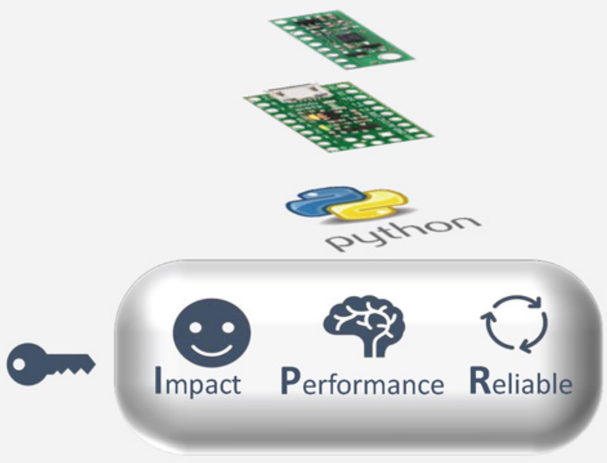


Capturing the simulated ROM data

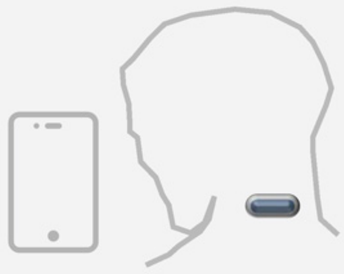


Data Interpretation

Realize



Phase-1



A NOVEL DEVICE THAT MEASURES THE CERVICAL RANGE OF MOTION AND IT TRAIN YOU TO PREVENT FROM NECK PAIN IS *Sway*

Sway

WEARABLE

FULLY CONFIGURABLE

AUTO CALIBRATION

REAL TIME DATA

USER FRIENDLY

AFFORDABLE PRICE

FOR CLINICAL ASSESSMENT

FOR REHABILITATION

FOR ALL AGE GROUP

Phase-2

** MVP Expectation*

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Luqman Marhim | Student
Soh Gim Song | Advisor

IMPROVING KICKING TECHINQUES IN FOOTBALL

PROBLEM

GOAL2034 is the target set by the Football Association of Singapore (FAS) to achieve the goal of reaching the World Cup Finals for the first time in the nation's football history. How do we help the football team to realize this dream by utilizing scientific research to improve player performance?

GOAL & AIM

Help the Singapore football team achieve GOAL2034 by enhancing player performance by designing a training tool/support to improve kicking techniques.

FACTORS

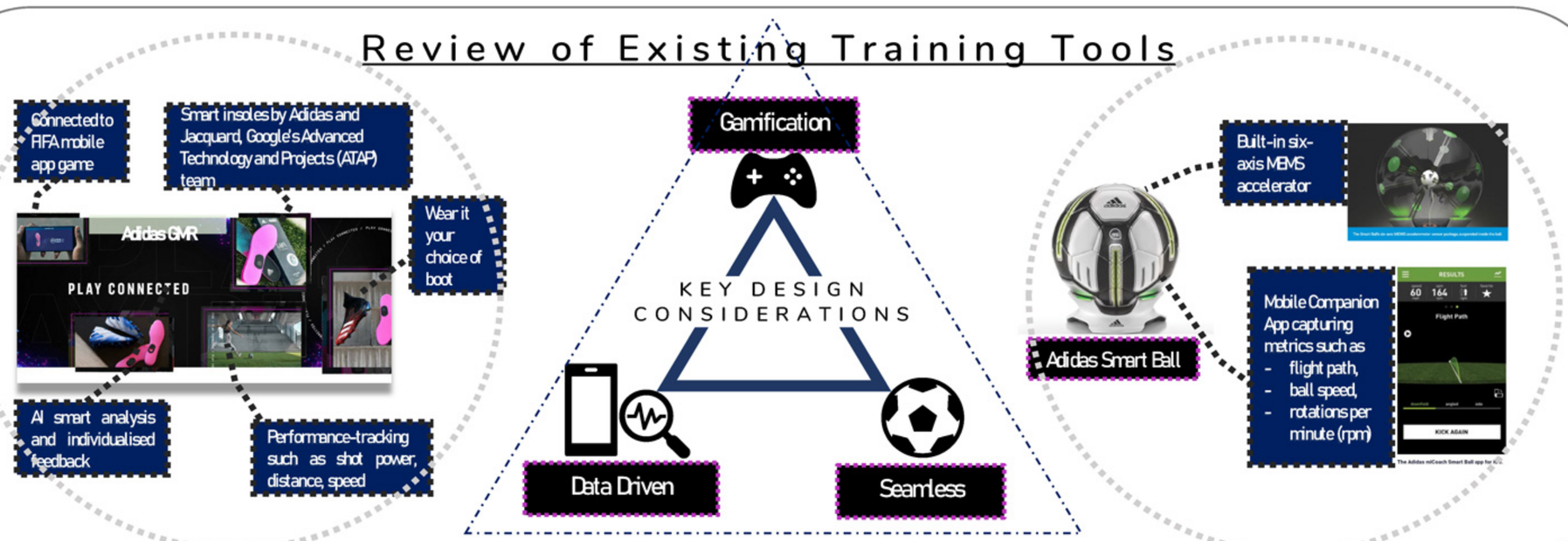
- Critical components of a Kick → Accuracy + Power
- Operational Definition of "Successful kicks" → Kicks resulting in the intended trajectory and ball speed

HOW MIGHT WE (HMW)

- HMW increase rate of a successful kicks by increasing accuracy in ball trajectory
- HMW increase rate of successful kicks by increasing kicking power to increase ball speed

IDEATE
PROLIFERATION OF IDEAS

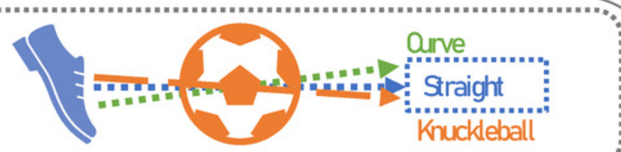
Review of Existing Training Tools



PROTOTYPE
DEVELOPMENT OF IDEAS

1. Optimal Kick Path

- Studies have been done to show there is an optimal kick path for different types of kicks and the existence of a "sweet spot" – point on the ball – that will increase the success of a kick



2. Execution of Kick

- User will select the type of kick he wants to execute e.g. straight kick
- User will then execute the kick

3. Analysis of Kick

- Football+ analyses the kick executed and compares it to the optimal kick path and feedback the analysis to the user

REALIZE
PRODUCTION OF FINAL PROTOTYPE

FOOTBALL+

Training aid to improve kicking accuracy

Wrist Strap + Smartphone App Feedback System

(i) Wrist Strap
- Wrist-worn → does not impede kicking process
- "Traffic light" colour system
- Immediate feedback

(ii) Smartphone App
- More in-depth analysis
- Track and monitor performance

Sensor

Sensor system slotted in insole of boot
- Unobtrusive → does not interfere with kicking surface
- Interchangeability → Insole can be interchangeable with different boots/shoes

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Prof. Mohan Rajesh Elara | Advisor

Framework For Selection Of Cleaning Robots Using Multiple Attribute Decision Making Approach

Why ?

Due to the increasing complexity in requirement and available features offered by various cleaning robots in the market, it is very important to have a framework to select more appropriate robot.

How ?

Provide standardized attribute-based specification pertinent to the stakeholder using Multiple Attribute Decision Making (MADM) approach, with quantified comparison and selection of best cleaning robots in the market.

What ?

A Framework outlining the standardized attribute-based comparison for Designers, Manufacturers, Suppliers and End Users to select the cleaning robot available in the market, that meets their needs.

Introduction

Cleaning robots are the machines that are used in the process of removing the visible and invisible unwanted substances from the working surface. These unwanted substances could be dry dirt, wet dirt, waste objects, infectious agents, chemicals, etc., Cleaning process includes dry vacuum, mopping, wet suction, dry foam, dry powder, hot water, chemical, air jet, disinfection, polishing, etc., The environment where the cleaning robot are deployed also ranges from industries, commercial building, offices, domestic, food courts, public parks, public roads, swimming pools, water tanks, ships, aeroplanes, etc.,

Reconfigurable pavement sweeping robot *(Source: SUTD)*

Commercial floor Cleaning robot *(Source: Lionsbot)*

UV-C Disinfection robot *(Source: Lionsbot)*

Shape shifting floor Cleaning robot *(Source: SUTD)*

Considering the rapid increase in the user requirements and the technological advancements, there have been many cleaning robots that are launched in the market. To select a cleaning robot, stakeholder has to look at different aspects, that includes the material to clean, the environment to work, the cleaning process to use, etc., It is very difficult and time consuming process for the stakeholder to understand all these aspects and find the cleaning robot. Therefore a framework needs to be created, that is simple but can be applied for all stakeholders, to ease the selection process and reduces the decision-making time.

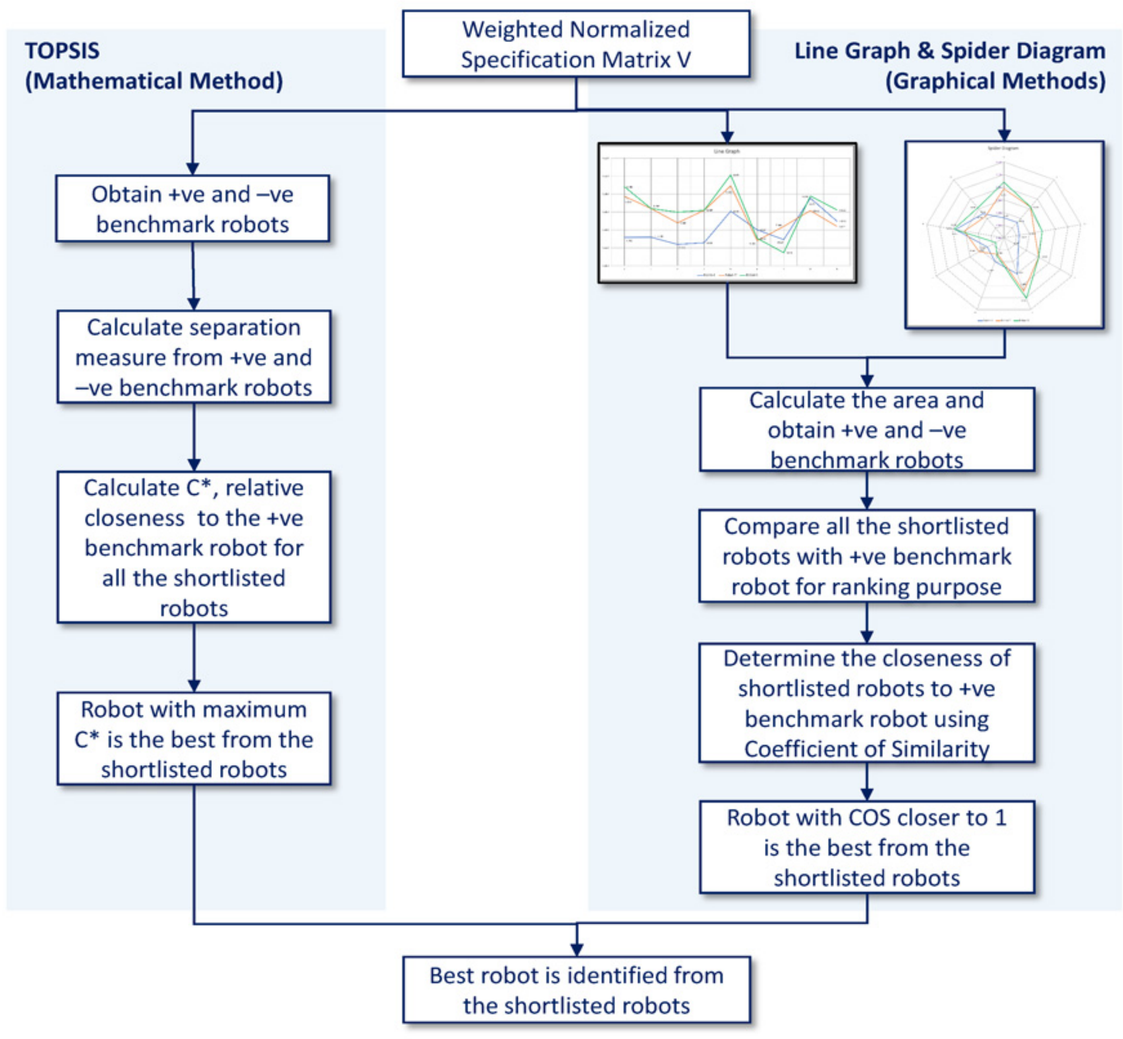
Ideate-Prototype-Realize

- Define the approach to be used for selection of cleaning robots
- Determine the attributes for properties for all identified components
- Document framework to select the cleaning robots for various stakeholders
- Literature Review: Study the existing methods used in the selection processes
- Identify various components used in cleaning robots
- Identify pertinent attributes that are critical for all the stakeholders
- Test the selection process with the cleaning robots available in the market

Selection Process

1. **Stakeholders**: Designers; Manufacturers; Suppliers; End Users
2. **Potential Robots**: Identify the list of potential cleaning robots available in the market, that meets primary needs of the stakeholder.
3. **Pertinent Attributes**: Apply all the pertinent attributes for the potential list of cleaning robots chosen from market.
4. **Obtain Values**: Obtain values for all pertinent attributes for all the potential list of cleaning robots from their authorized source.
5. **Evaluation Matrix**: Assign value to objective and codes to subjective attributes. Apply weightage to these attributes and form a matrix.
6. **Finalized List**: Evaluate and Rank using mathematical & graphical methods. Finalized the cleaning robot for the specific stakeholder.

Evaluation and Ranking Methods



Conclusion

The framework helps the stakeholder with a simple and easy selection process. This avoids time and effort for stakeholders spending on exploration and research, to identify their appropriate critical attributes for their selection process. Though the process defined in this framework is specifically for selecting cleaning robot, this framework can be extended for any other robots with the refinement to the properties and pertinent attributes for the type of robot that are involved in the selection process.

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Chitosan Based Organic-Inorganic Composites

Applied in Additive Manufacturing

Ideate – Bioinspired Design

From Shrimp to Metals

What is Chitosan?

Chitosan is a biopolymer derived from Chitin, the second most abundant naturally produced organic material. It is usually derived from insects and shellfish like shrimp. When cured it produces extremely strong sheets which mimic modern plastics.

Chitosan is being explored as a sustainable material for use in fields like medicine and consumer goods. However there are several Challenges:

A. Chitosan polymerises well in the X & Y axes, but not Z.
B. Chitosan polymerises as it loses moisture content.

How can Chitosan be utilised in building larger three dimensional structures?

A potential solution lies in composite materials.
Chitosan exhibits good bonding with materials, and exhibits chelating properties, binding well to metals. Chitosan cures into a solid once it's moisture content has evaporated. These behaviours can be utilised to solve the two key challenges:

A. Metal powders can be used as the aggregate material, bound by a Chitosan matrix, thus forming composite.
B. Chitosan-Metal gel can be shaped in any manner at room temperature, and will solidify into a solid object once moisture evaporates.

Prototype – Developing a New Composite Material

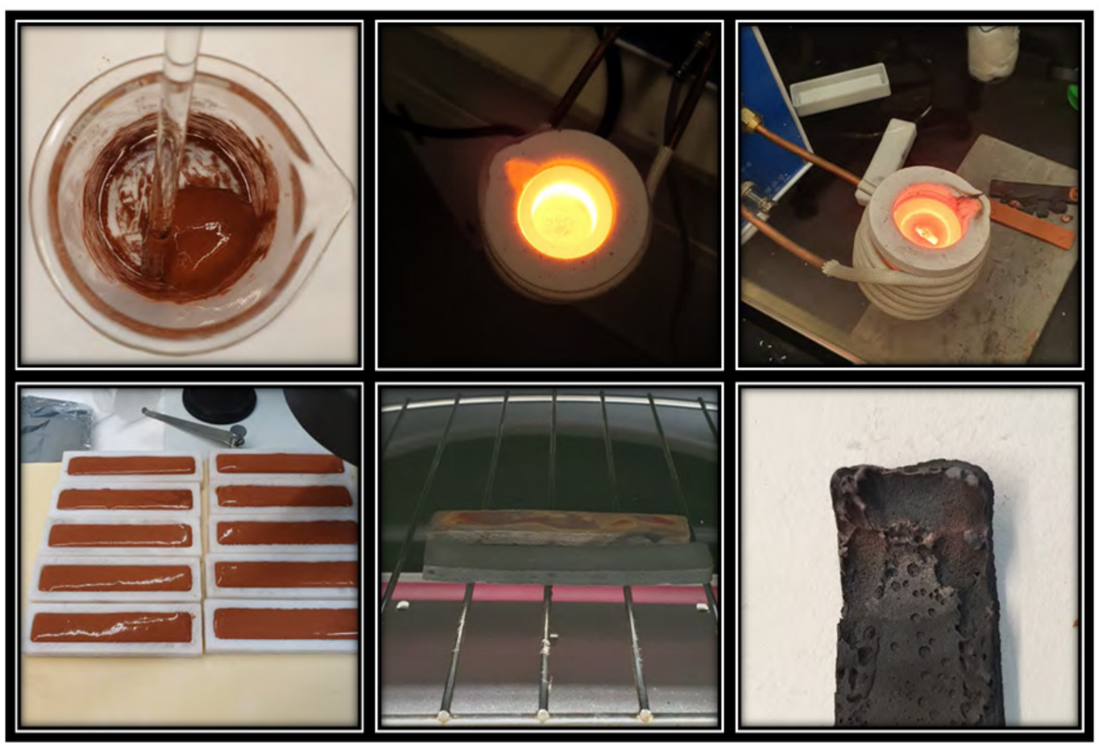
Methodology for cold shaping metals

The objectives of the prototyping phase were:

1. Develop a suitable working composition of Chitosan-Metal paste
2. Develop a methodology for using the composite
3. Discover how to refine the composite into finished products

The following discoveries and innovations were achieved:

1. Irregular metal particles bond better than spherical particles.
2. The paste can be extruded into shapes or cast in moulds at room temperature, making it viable for extrusion 3D printing.
3. Oven dried samples are solid and can be melted into liquid metal.
4. Using a benchtop induction heater allows melting of metal in the composite.
5. Melting the metal allows the powder to fuse into a solid metal piece

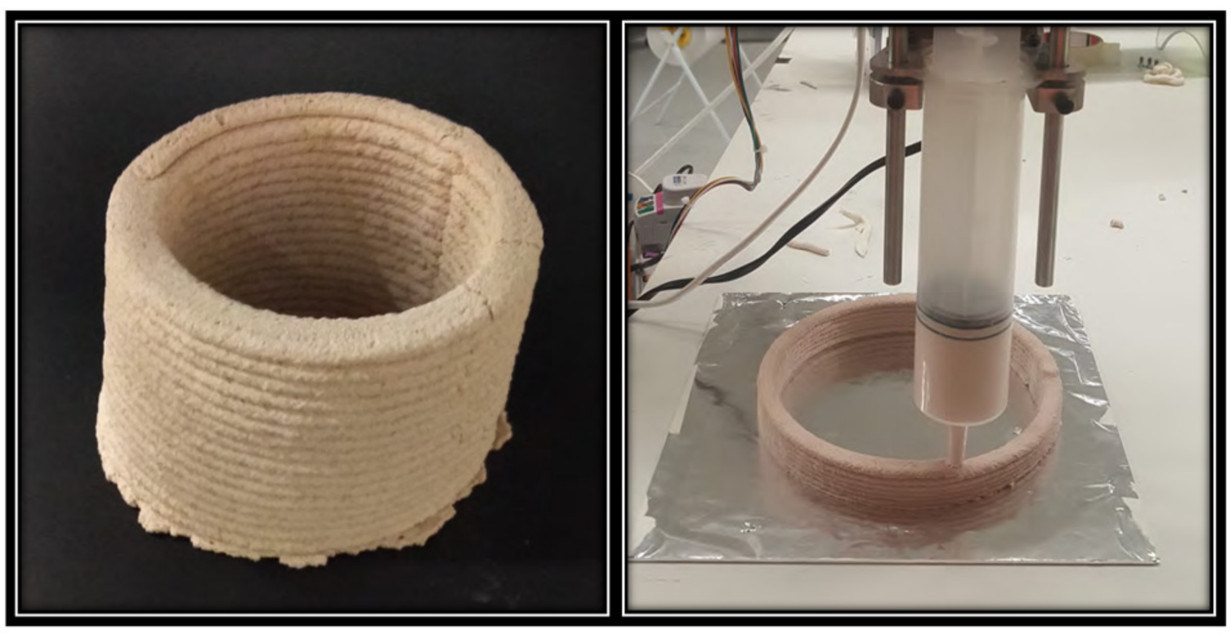


Realise – Future Applications of Chitosan-Metal Composite

With the Chitosan–metal organic-inorganic composite, several potential applications can be explored.

The first application is Chitosan based 3D printing. Similar methods have been developed before using Chitosan fused with cellulose (FLAM) or calcium carbonate. Using metals as the aggregate ingredient imparts the metal's properties to the composite.

The second application is low-cost metal fabrication. Conventional metal production uses expensive equipment. Using this composite, objects can be crafted in moulds or even 3D printed at room temperature, thereafter being heated until the metal fuses together, resulting in a solid metal object. This makes metal production accessible to hobbyists and the backyard scientist for rapid prototyping, jewellery production etc.



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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Ng Jian Yi Mervin | Student
Michinao Hashimoto | Advisor

4D Printing

deForm: Freeform surfaces from controlled shrinkage in 3D printed planar structures

MOTIVATION

Why

In Additive manufacturing (AM) processes, when temperature control is involved, there are common inaccuracies caused by warping, cracking and bending due to material shrinkage.

How

If we understand this phenomena and predict these situations, not only can we reduce the inaccuracies, but we can also use it to create 3D geometries without the use of structural supports, which also eliminates material wastage and reduces the time for printing.

What

The aim is to develop a prediction model after investigating factors that can control material deformation, so designers can achieve desired 3D geometries just by printing them in 2D.

- What is the significance of material deformations affecting additive manufacturing processes?
- Do material deformations improve physical and mechanical properties of the material?
- In what way can material deformations be controlled or predicted based on specific needs?

FOCUS

Deformation Mechanism

The main mechanism to be studied is bending, driven by thermal control. By varying printing parameters for different layers, the shrinking rate is different for each layer. The direction of deformation is perpendicular to print direction. These factors can provide interesting deformation behaviour in various print patterns.

Materials

After investigating Shape Memory Effect, a Polyurethane (PU) based Shape Memory Polymer (SMP) is chosen to study. SMPs have the unique characteristic of being able to 'memorise' a permanent shape. If heated beyond its glass transition temperature (Tg), it reverts back to this memorized shape.

Modelling

The aim is to devlop a parametric workflow from start to finish. Based on desired geometry, a planar geometry is generated by the simulation model, which is then subsequently computed into geometric code to be sent for printing, with the relevant parameters essential for accurate deformation.

Printing Process

In extrusion based AM processes, there are many variables involved that affects material shrinkage. To have a clear understanding of the relationship, a matrix of these parameters is designed for experimental study before determining the optimal deformation process.

Research Plan & Approach

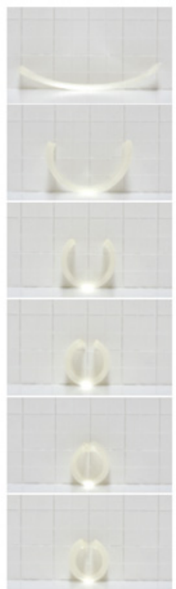
- Literature Review
- Parametric workflow - geometry to G-code
- Characterization of shrinkage factors
- Experimental Study (pattern design)
- Run simulations to optimize deformation

Design of experiment

Hypothesis:

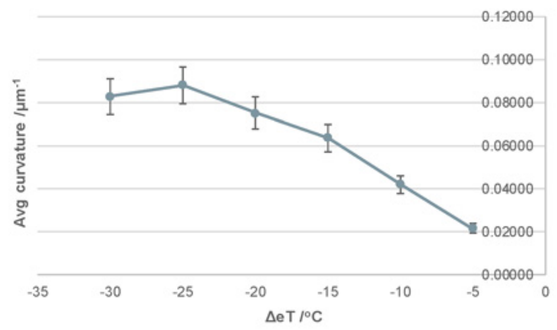
1. The greater the difference in ***extruder temperature*** when printing the base and upper layers, the greater the shrinkage in the overall structure.

Temp_extruder:
eT | 180 - 210°C



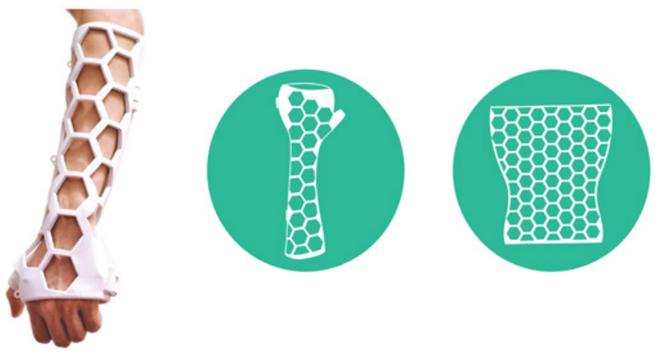
eT / °C	curvature / μms^{-1}
210 | 205	0.02160
210 | 200	0.04228
210 | 195	0.06388
210 | 190	0.07530
210 | 185	0.08815
210 | 180	0.08293

Fixed Parameters



Expected Results

An entrepreneurship project - CASTomize, will be an application of this tool.



Additional Benefits:

- No need for joints as deformation can serve as mechanism for patient to wear the cast
- Shape memory effect allows ease of removal and efficiency in storage and transport.

Academics

Thorough understanding of material shrinkage factors builds more layers of foundation in search for potential applications.

Practice and Industry

This versatile tool can be beneficial to AM users and designers. Apart from material and time reduction, the movement of material deformations can be more creatively used in design processes.

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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< Lucienne T.M. Blessing> | Advisor

Function Modelling: A Novel Function Modelling Framework for Complex Software Design

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Engineering Product Development Department | Singapore University of Technology and Design, Singapore.

Background

What? Function models describe and visualize the functionality of the system to be developed.

Relevance? Software development community has been using numerous function modeling approaches over past few decades to conceptualize software systems.

Situation? It has been proven that majority of people prefer to design software without using a proper function modelling approach because of numerous shortcomings in each approach, even though it is essential to use function models in designing complex software systems. Most widespread difficulties stated related to current approaches are high complexity, inconsistency, incompleteness and time-consuming behavior.

Problem? Lack of usage of function models in early design stages leads to poor quality software products while failing to meet expected business goals.

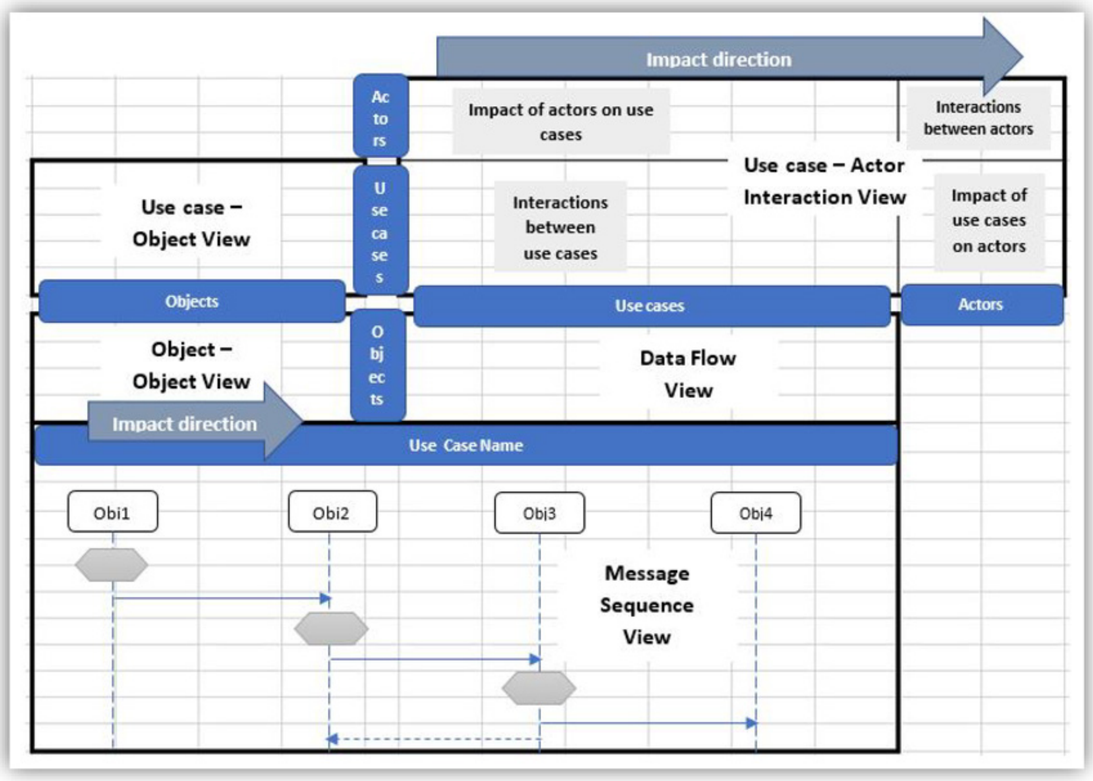
Project Aim, Goal and Focus

Aim (Why?) Enhance the quality of software products by encouraging people who work in software development discipline to use function models more adequately in early designing stages.

Goal (What?) Develop a simplified function modelling framework for software community to conceptually design complex software systems.

Focus Identify most significant features of current function models and apply them in designing a simplified function modeling framework, through analyzing benefits and shortcomings of each model.

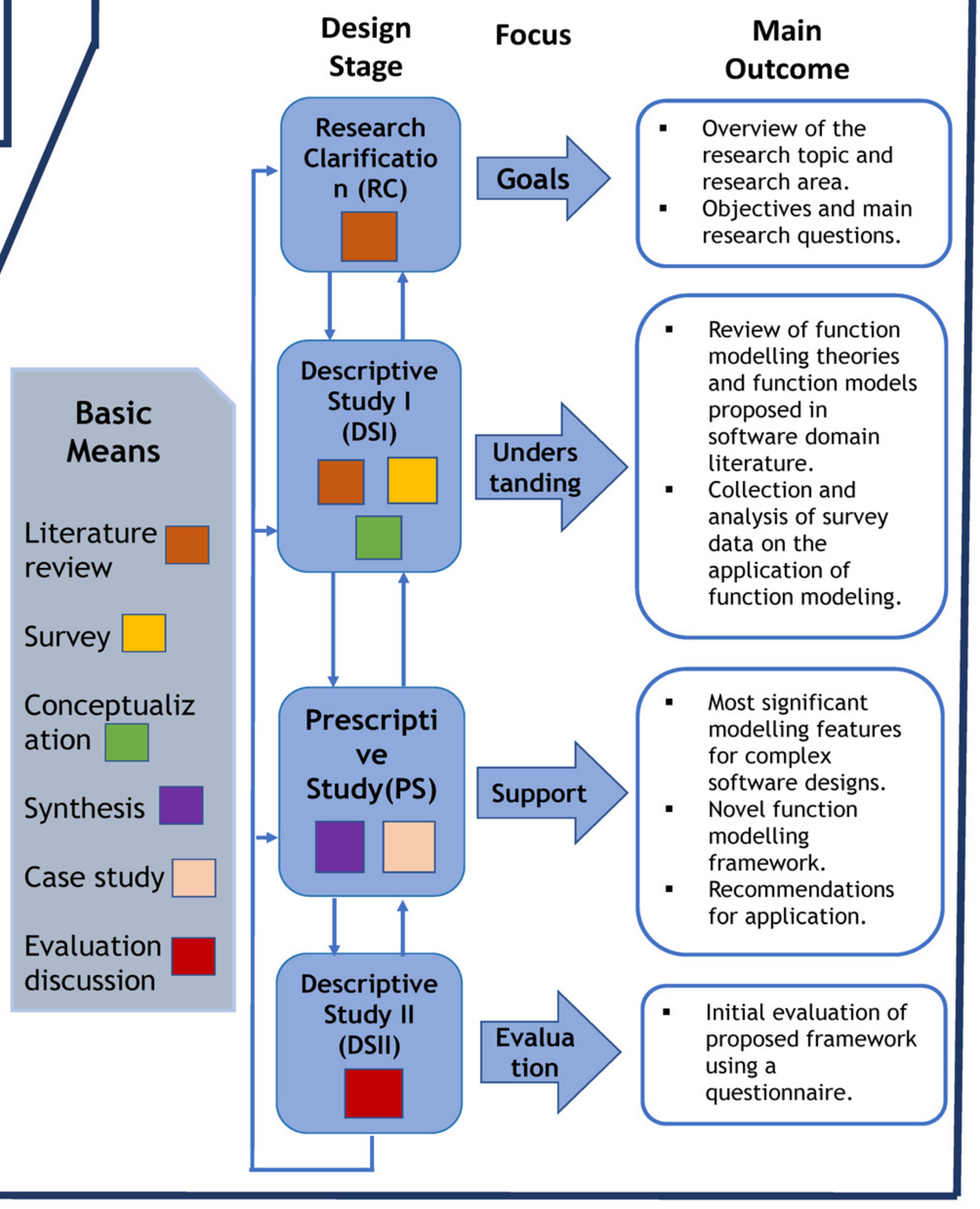
Object-Oriented Function Modelling (OOFM) Framework



Key Benefits

- Summarize all modelling aspects in one place using a matrix-based representation.
- Clarity of visualizing the content and solutions, hence enhance the understandability of the overall system.
- Enhance the collaboration between the teams and clients.

Design Approach



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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

<Shen Tianruo > | Student
< Liu Xiaogang > | Advisor

Small But Red

A General Molecular Design Rule to Cerate Long-wavelength Dyes

Introduction

In the design process of fluorescent dyes for dye-sensitized solar cells and biological cell stains, small molecular size and large absorption wavelength have always been the focus for the researches to achieve the characteristics of easy synthesis, low effct on cells and overlap with sunlight.

Nowadays, there are three ways to realize the "small but red" in the donor-π-conjugation-acceptor (D-π-A) dye design: 1. changing the positions of substituents; 2. changing the types of substituents; 3. enlarging the π-system.

The group of Sergei reported two dyes with a thiophene unit in the π-bridge, differing from the position of methine unit, which create a absorption maxima diference of 61 nm in the dioxane to 139 nm in the dimethyl sulfoxide. However, there is no good computational method to reproduce the experimental phenomenon or explain the difference.

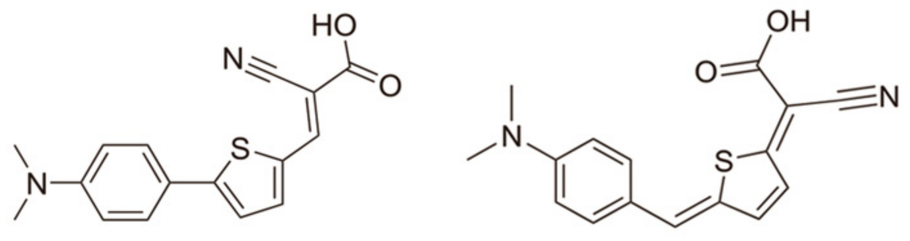

Fig. 1 The molecular structures of dye 1 (left) and 2 (right).

Main Questions

1. Which computational method can reproduce the experimental phenomenon?
2. What does changing the methine unit position cause a large difference in the absorption wavelength maxima?
3. Can this design strategy can be promoted?

Research Approach

1. **Wavelength Calculation**: The experiment in dioxane was restored in using the ωB97XD functional with Liner Response solvent method (Fig. 2). The large in the difference in DMSO is due to the dehydrogenation of dye **1**.

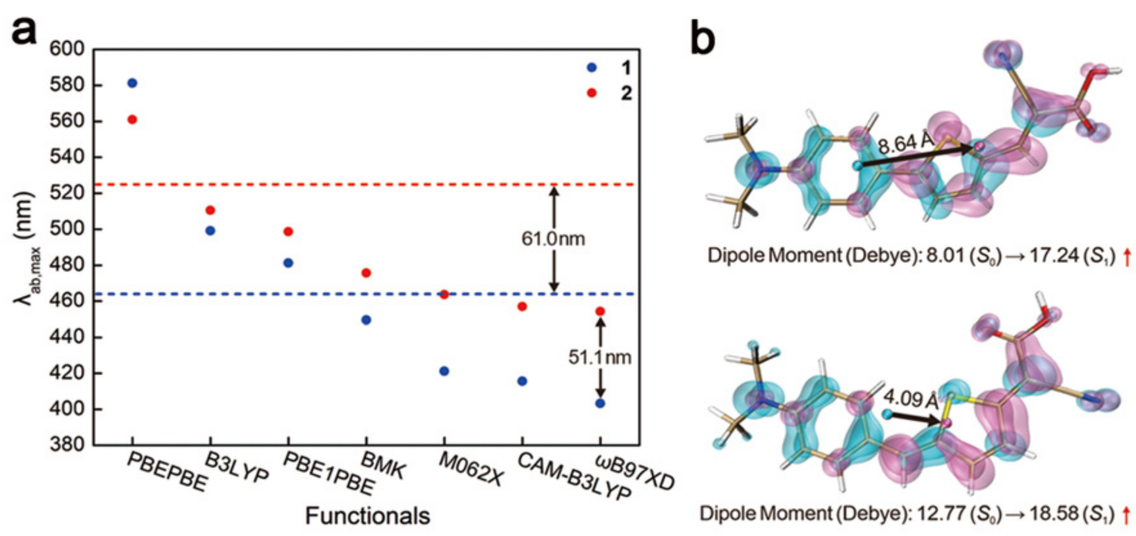

Fig. 2 a. Absorption wavelength maxima of two dyes in 1,4-dioxane by using 7 functions; b. Centroid distance and dipole moment of dye **1** (up) and **2** (down).

2. **Structures Analysis**: Geometrical structures (bond-length alternation) and electronic structures (orbital gap and charge transfer degree) are detaliedly analyzed to explain the difference between two dyes deeply.

3. **Molecular Design**: Series of molecules are designed by the bridge, donor and acceptor modification. Two dyes (**1f** and **2f**) with long wavelengths in the nonpolar solvent are

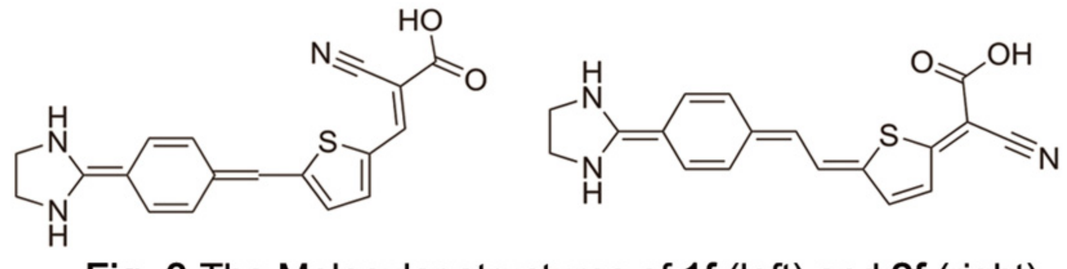

Fig. 3 The Molecular structures of **1f** (left) and **2f** (right).

Goal

1. Finding out the best computational methods to reproduce the experiment via the Gaussian 16 program.
2. Providing a feasible design strategy for the "Small but Red" organic dye.

Deliverables

1. A paper or report for the study on the deep investigation of the two dyes.
2. Series of large absorption wavelength and coefficient chemicals via exchanging the conjugation order.

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Fluorescence Research Group

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Shravya Thandlam Sudhindra | Student
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RESEARCH APPROACH

This project follows the DRM Reseach approach

1st stage - Research Clarification -
Based on literature, the main focus was set.

2nd stage - Descriptive study (DS1) -
Studied the structure of assessment of langugae and music which contributed toward finding answers to the research questions.

3rd stage - Prescriptive study (PS1) -
Synthesis of a new framework –the Design Competency Assessment (DesCa) framework.

4th stage - Descriptive study (DS2) -
Evaluated by two design faculty at SUTD and instantiated as a prototype for one design course (3007).

5th stage - Prescriptive study (PS2) -
Figma (an online interface tool) was used to create a digital wireframe that illustrates the overall design of the framework and the process of using it.

01
Hypothesis
Different levels of design competency can be identified and defined irrespective of the discipline / design task.

02
Hypothesis
Every stage of the design process requires specific skills that contribute to better insights.

03
Hypothesis
Assessing the design competency of an individual contributes to progress in design learning.

1 DESIGNING & PLANNING of design learning curriculums

Providing a clear and comprehensive framework

- All aspects of the design learning process is covered across and through the framework (The design process along with accompanying tools, objectives, tasks and skills are explicitly laid out)
- A detailed framework is offered depending on the course with suggestions on efficient practices.
- All parts of the framework are customizable by the instructor/the program administration.

2 DEVELOPMENT of design skills with use of tools & methods

Objective identification of all relevant skills for each phase, each step and each task of the design process.

- DesCA offers instructors a list of skills that are highly recommended for each phase of the design process and based on design tasks/deliverables.
- Students can now identify skills that they have, need to acquire and those that need improvement.
- Offering skills as learning objectives allow learners to choose programs/courses that target specific skills in addition to their interest in a certain discipline.
- Design tools/methods are suggested to compliment skills that are needed/acquired by design learners.

3 MONITORING growth & progress in learning

Easy tracking of performance based on set expectations, learning outcomes & scope for improvement.

- DesCA's enables course leads to define expectations using a Learning Expectations and Outcomes (LEO) matrix. This determines the 'level' of the course. Instructors can then translate this into level appropriate studio tasks and facilitate the use of associated skills. This also allows students to plan their work to meet these course goals and aim to move up these levels.

4 ASSESSMENT / EVALUATION & feedback to design learners

Increased transparency in evaluation criteria, break - up of scores and area of individual improvement.

- Final grades/scores can be back tracked to scores awarded for a set of skills associated with each step of the design phase/design task in the design process.
- Assessment and evaluation is based on skills acquired, in addition to the evaluation of design deliverables as usually done.
- This provides a more accurate grade/outcome with minimal dependance on subjective/individual interpretation of the evaluator.

5 INTEGRATION of design industry needs

Timely updates and revision of existing courses/curriculums based on the changing needs of the design industry.

- The framework suggests skills, tasks and terminology based on current trends in the industry.
- Updates are offered in terms of suggestions when new trends/skills or needs arise in the industry. This ensures education is at par with the industry.

6 IDENTIFICATION of design competency

An accurate indication of the design knowledge and skills an individual has at the end of the designed course/program.

- All programs that use DesCA to design their curriculum can set their offered 'level' of design competence depending on the course(s) they offer.
- Student's final design competency is issued as a grade. This grade is indicative of the strength/expertise at a certain level.
- Adopting these levels will help learners choose courses and help instructors/ employers identify design competencies.

7 SUPPORTING class & lesson planning

The complete design learning structure urges instructors to plan lessons based on skills needed to complete design deliverables and design tasks.

- Besides offering tools/methods for completing design tasks, DesCA requires instructors to integrate these tools / methods with other content (visuals, models, examples, etc) to scaffold instruction.

DesCA
DESIGN COMPETENCY ASSESSMENT FRAMEWORK

A COMPREHENSIVE STRUCTURE TO ASSESS DESIGN COMPETENCY AND MONITOR PROGRESS IN DESIGN LEARNERS.

! PROBLEM STATEMENT

The increase in the use of design has created a demand for designers and design education. Many institutes offer programs and courses in design and assess the level of design expertise.
However, there is no common reference system to:
(1) Identify and assess the design competency of learners, and the level of competency aimed for by a course.
(2) Universally recognize the design competency 'level' of an individual or course.

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Siddarth U. Raghavan | **Student**
Prof. Lynette Cheah | **Advisor**

Geo-Spatial Analysis Of Singapore's Household Energy Demands

Introduction

Singapore Households makeup 14% of total electricity demand in Singapore in 2019. 80 % of the population lives in a total of 1.06 million dwelling units of public housing estates (HDB estates).

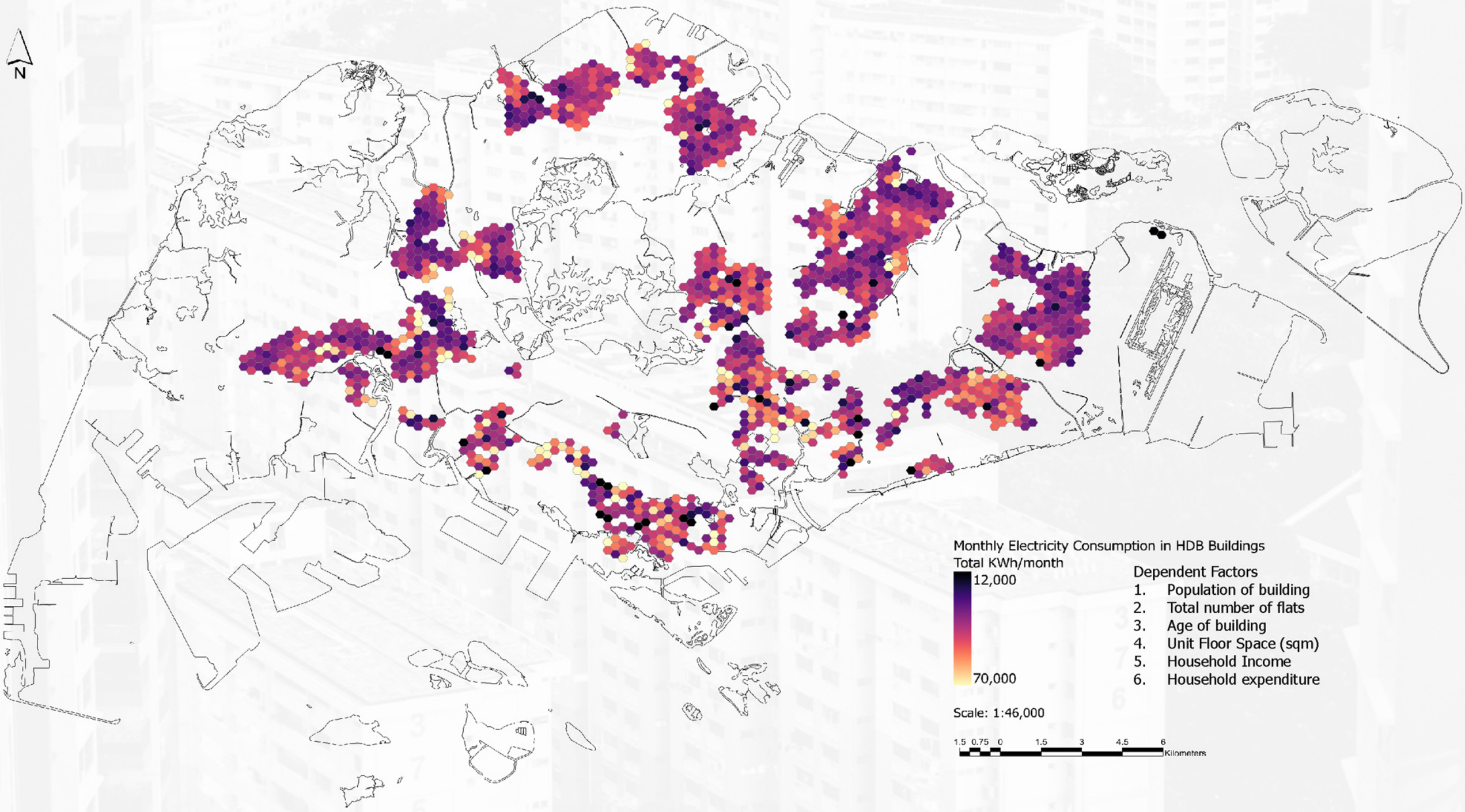
Design Aims

1. **Map** high-resolution maps of electricity consumption in HDB buildings.
2. **Identify** statistically significant factors electricity consumption within HDB estates.
3. **Analyze** the main factors which lead to the geo-spatial difference in electricity consumption.

Main Contributions

Urbanization & Sustainability

1. First round **Hi-Resolution** maps to detail the energy performance of all HDB buildings.
2. An effective method to match BCA 'Green Initiatives' to HDB estates.
3. Optimization of New Energy Efficient HDB estates



Key Findings

Different **buildings** consume **different** amounts of **electricity**.

1. Building **Population**, Number of **Units** & **Age** of Building have **positive & significant** impact on Electricity consumption.
2. Household **Size, Income & Expenditure** are **not** significant indicators.

At the **Town level**, there was **no significance** indicators found to **explain** the **difference** in energy consumption.

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Pablo Valdivia y Alvarado | Advisor

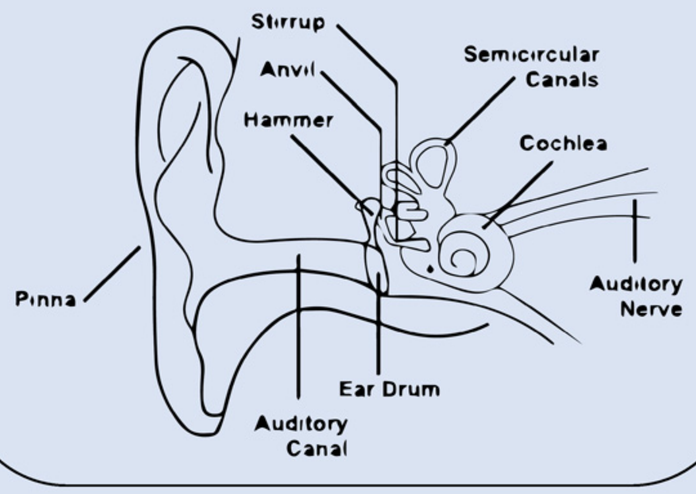
DEVELOPMENT OF A SOFT INERTIAL MEASUREMENT UNIT FOR USE IN SOFT ROBOTICS

Soft Robotics is a relatively new concept in the field of robotics, where robots are made from compliant materials to withstand deformation. This provides an advantage over traditional robots as the compliance could allow for the soft robot to operate in harsh conditions, or to provide a safe working environment where humans and robots work together in close proximity.

An Inertial Measurement Unit (IMU) is used in robots for motion and control. A soft robot would work better with an IMU that is equally compliant, while providing accurate and reliable motion readings. Therefore, IPR was done to develop a Soft IMU.

IDEATE

Human Inner Ear: A Natural Soft IMU

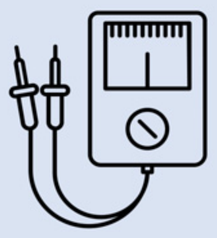


Motion is detected through the movement of fluids in the semicircular canals.

Methods To Detect Movement Of Fluid

Using a Piezo Resistor

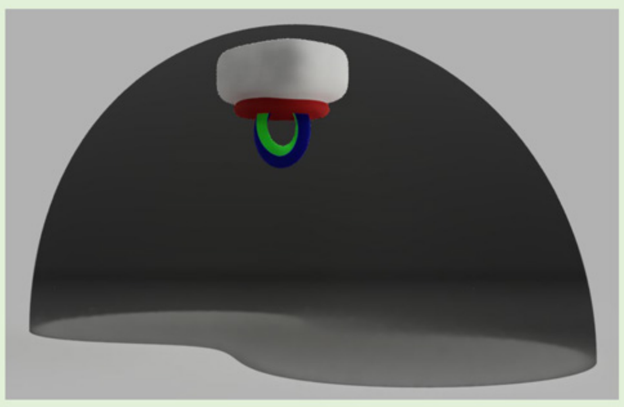
Thermal Measurement



Potential Difference

Computer Vision

PROTOTYPE

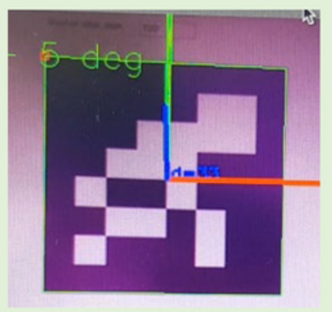


CAD Model Of Sensor Position In Soft Robot Body

Using Computer Vision

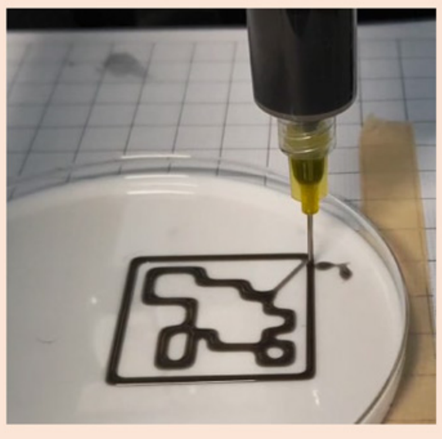
Markers Made Up From Black And White Grids Can Be Detected By Computer Vision

Using A Raspberry Pi Board And Camera



To Give Position Estimates

REALIZE



Printing Of Marker Using PDMS Ink

Alternative Way Of Printing Via Injections

After printing the marker, it is left to cure into a piece of soft PDMS. The marker is placed in fluid to achieve buoyancy, such that any displacement of the soft robot will cause the PDMS marker to displace as well.

By placing the camera in line with the marker, Computer Vision can be utilised to detect the change in motion, and the information is processed by the Raspberry Pi to give the displacement of the soft robot.

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Subburaj Karupppasamy | Advisor

MotivAID

Aiding Motion through Motivation

Design Opportunity

- User suffered infantile spasms causing lasting damage in mental and physical development.
- Sedentary lifestyle has lead to high BMI, requiring walking exercise.
- Requires heavy assistance on father and helper to stand and walk, who struggle with her weight.
- Her decreased self-awareness hinders drive to increase personal mobility and physical wellness.
- Existing walkers on market are large and bulky and designed with a medical aesthetic, while the smaller, compact ones offer insufficient support.

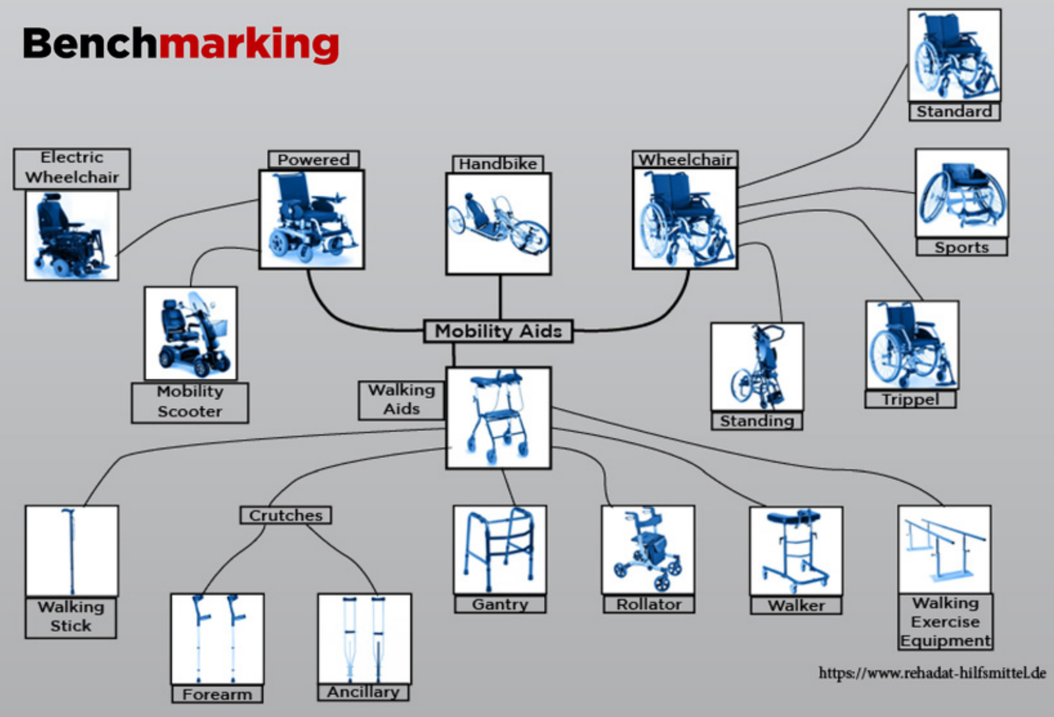
Problem Statement

How might we design an assistive walker that is highly functional, encourages pride of use and ownership, and motivates voluntary engagement?

Scenarios & Insights

Scenarios	Insights
Patient is going down a slope without direct support, feels unstable.	Walker should provide a speed limitation to prevent uncontrolled/undesired acceleration, and enable stable movement in intended direction.
While outside of home, the patient's caretaker has to divert his attention to purchase food, leaving the patient unattended.	Patient should feel calm and relaxed while left alone on the walker for short periods of time. It should also be safe enough for her to be left unattended.
Patient goes on a road trip with her father to Malaysia, and is excited to explore the new environment but is restricted to her wheelchair.	Walker should be compact enough in stored state to be kept in car boot, and be able to replace wheelchair in most scenarios e.g. short distances.
Patient loses her grip, being unable to support her weight any longer and falls to the ground.	Walker should possess a failsafe system that supports the patient only when she releases her grip.
Patient feels tired and lazy after a short walk and chooses to sit on the integrated seat, refusing to walk any further.	Walker should provide an integrated seat that is convenient enough to deploy for rest but does not provide access at patient's disposal.
Patient is using the walker and a passer-by accidentally collides into her.	Walker should be stable enough to retain balance upon external impact. Arm-holds should be comfortable and easy to grip.
Patient is using the walker and in her excitement, knocks into an old lady holding a bag of groceries.	Walker should be highly visible such that people nearby are able to see it coming. There should not be any sharp protrusions or hard edges.
Patient is using the walker when an unexpected rock/pothole/kerb strikes her foot/wheel and she tumbles over.	Walker should be designed in such a way that any foreign objects in the path are only contacted by the walker instead of the patient's feet.
Patient is waiting on her walker in the carpark while caretaker is facing away. She starts walking into the path of an oncoming car.	Walker should possess a restricted movement mode to ensure that the patient stays in the same spot in dangerous environments.

Benchmarking



https://www.rehadat-hilfsmittel.de

Prototype Testing

Parallel Prototyping

Prototype 1

- Integrated seat through swivel mount
- Large and bulky
- Full support and rest position available

Prototype 2

- Minimal support, requires more effort from user
- Allows for more strenuous training while walking

Prototype 3

- Basic box frame design
- Baseline for comparison

Synthesis & Analysis

Prototype	1	2	3
Pros	Large stable resting position able to substitute wheelchair	Well balanced Compact Open feel	Rigid and stable Simple, compact design
Cons	Too large and bulky, difficult for user to manoeuvre Difficulty passing through tight spaces	Extended rear wheel positions provide stability but interfere with user's foot movement	User looks/feels too enclosed Arm supports on the sides are not ideal
Conclusion	Prototype 2 had the best results of all. To integrate ideas such as seating position for rest, additional handgrips. To fix issues with extended rear wheel position.		

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2019/2020 Ideate-Prototype-Realize



SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

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Prof Belinda Yuen | Advisor
Prof Arlindo Silva

Harnessing Mobile-based Technologies for Caregiving of Persons with Dementia

First symptoms
(Managing sudden events)

Tests/diagnosis
(Searching for answers)

Treatment
(Making adjustments)

Ongoing management
(Looking for support)

The long goodbye
(Balancing expectations)

Bereavement
(Coping with loss)

(Source: AgingWell Hub and Caregiver Action Network)

Information and support services are mapped to the different stages of a caregiver journey

Reorganised informational resources from the Dementia Friends mobile app to six stages of a caregiving journey

This project reviews, builds on and extends the existing Dementia Friends mobile app for different caregiver profiles.

Empathise | **Define** | **Ideate** | **Prototype** | **Test**

Design Phenomena

The complexity of supporting families of persons with dementia (PWD) encompasses a multitude of issues.

Problem/ Opportunity

An online survey on the use and effectiveness of the Dementia Friends app found that the barriers to access information and support services for caregiving of PWD are due to lack of awareness and features for caregivers.

Desirable Outcomes

Reduce caregivers' burden and improve their capabilities in management of care by matching caregiver needs to informational resources using mobile technologies.

Future Development

A caregiver app that will help caregivers to increase social connectivity.

Prototyped app design

Caregiver profiling

Targeted information

Useful support features

Future development/ Recommendations

Reimagining the caregiving journey through co-creation

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SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Xiang Maoyang | Student
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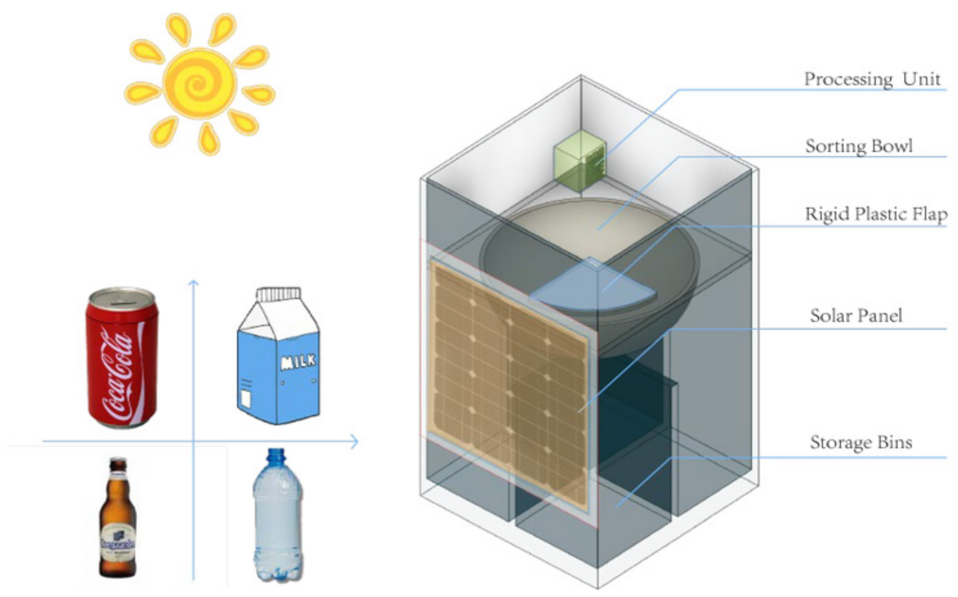
This project presents an AI driven Energy Efficient Recyclable Bin which sorts the recyclables into 4 types including metal, plastic, paper, and glass.

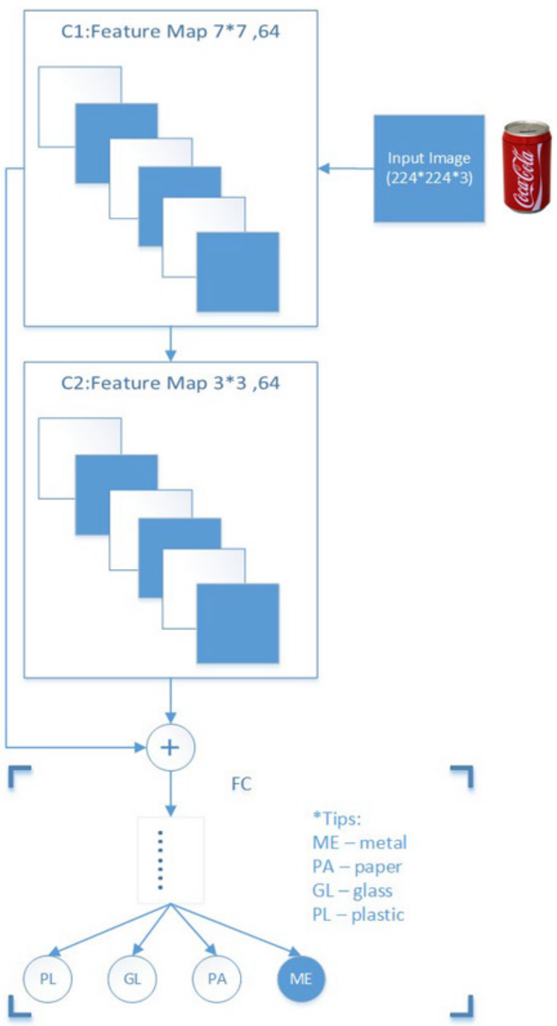
The image of the recyclable object is captured via camera, and will be classified and processed by the depth neural network. After processing, the operating system drives the servo mechanism to complete the classification of recyclables. Through this energy collection system, the above embedded system can be guaranteed to run without power grid.



The design of an AI driven energy efficient recyclable bins

Background

From the perspective of economic and social development, it is an **inevitable trend** to realize efficient **utilization** of resources through garbage classification.
But there are some problems.
>Due to the lack of knowledge in garbage classification, it is difficult to **promote** garbage classification at the **individual** level.
>With the development of deep neural network(DNN), there are many complex networks that can complete the task of garbage classification and recognition. However, most DNNs require a lot of **computing resources**, which is not **conducive** to garbage classification at the personal level.



The picture shows the deep neural network(DNN) structure customized ResNet-18 which has deployed on PC and our embedded computer vision system. ResNet DNN is less likely to degradant comparing to others DNN.

Research goal

> To develop an energy efficient solar energy harvesting system;

> To develop a low-power embedded computer vision processing system;

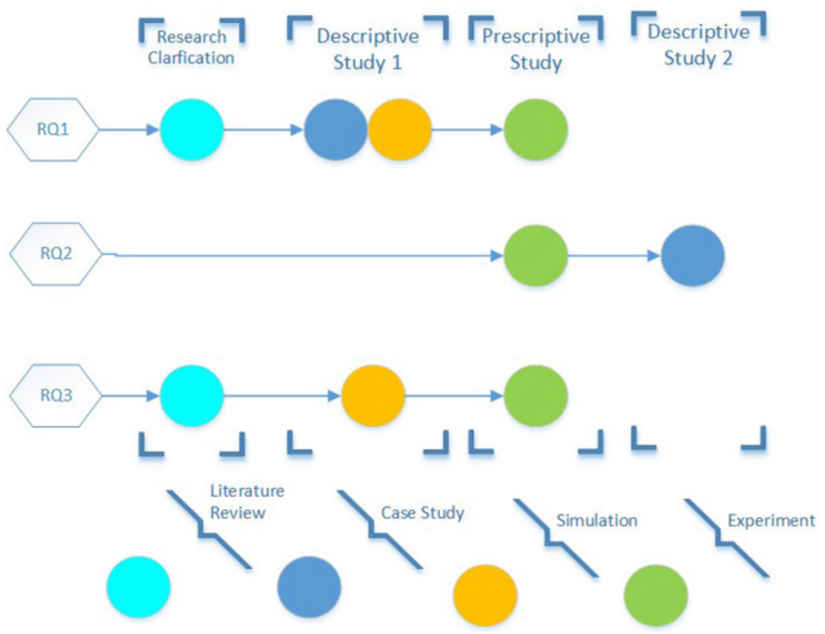
> To develop a less computing cost neural network framework which can be deployed on multiple platforms;

> To improve clock allocation of computing system to balance the power consumption and computing performance;

Question & Approach

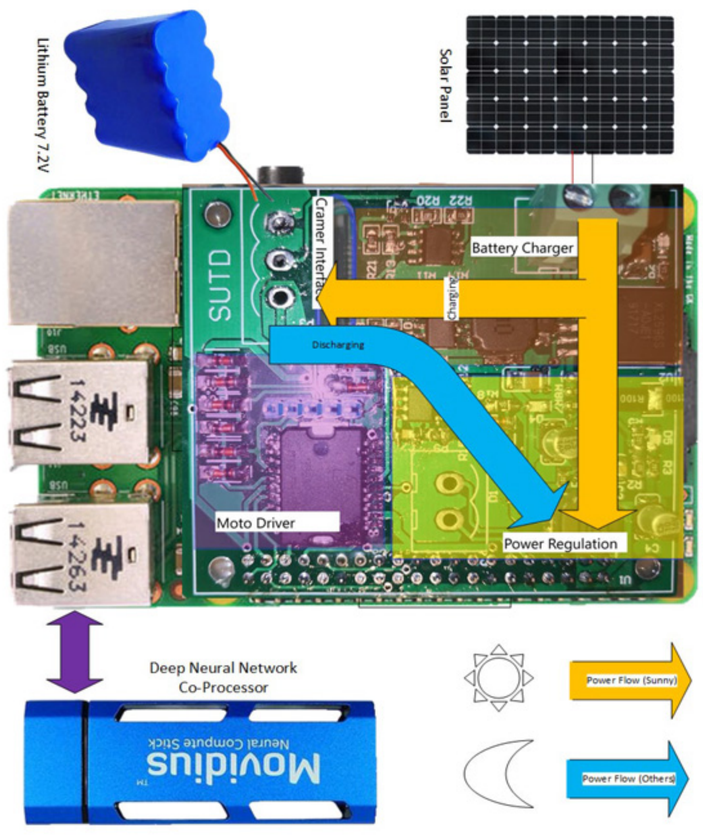
Research Questions:
RQ1: What build an **efficient** energy harvesting system?
RQ2: How can the system wake up to ensure the **timeliness** of processing?
RQ3: What **data types** should be used in neural networks to reduce computational cost?

Research Approach



Expected results

- The development of a device can realize the automatic classification and recovery of common garbage which can be deployed in a variety of **public places** e.g. out space of HDB, outdoor park;
- Develop **a large scale** collecting system based on a amount of deployment of our former devices to establish a resource **recovery system**;



When it's sunny and brighten, the solar panel(19.1V) collect the solar energy which charge the Li-ion battery and transfer to the regulator to supply the processing unit and driver(5V).

Your participation

Our project is followed MIT License. The source code is available on Github. Scan the following QR code and join us.

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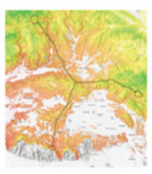
SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

ZENG Xinyu, Gabrielle | Student
A/P Bige Tuncer | Advisor

Sense of Place and its interplay with Arts in its creation of values in the Community



map out the different layers of information (different art places and the residential sales price) over **Geographical Information System (GIS)**

Multi-variables linear regression to examine the relationships between art places and property prices

Survey to understand the social impact of art places to community

Ideate

The impact of art development in Singapore is **not well studied and quantified** , resulted misallocation of resources by the various stakeholders (planners, artists, public, and financial institutions)

The aim of this I-P-R project is to To quantify the **socio-economic impact** of art development in Singapore and give urban planner advise on their planning process.

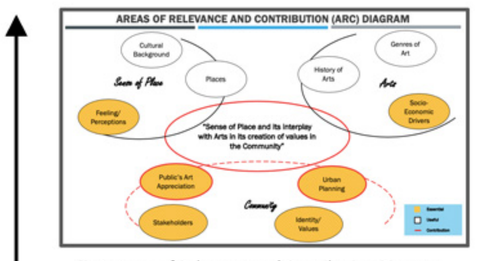


Fig 1: Areas of Relevance and Contribution Diagram

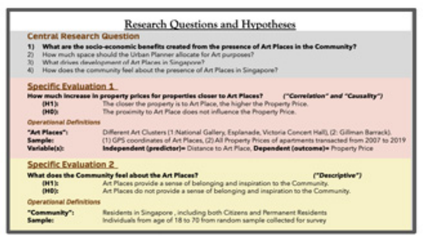


Fig 2: Research Questions and Hypotheses

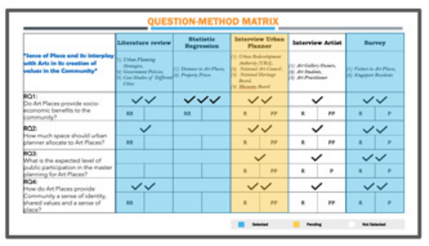


Fig 3: Question-method matrix

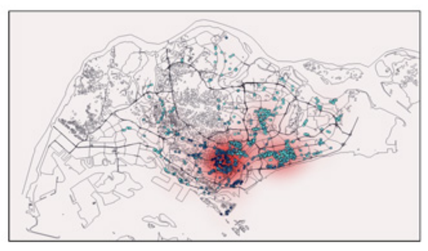


Fig 4: Heatmap of 200 art places in Singapore

Prototype

- Literature Review
- Heatmap of Art Places
- Heatmap of Property Prices
- Statistic Regression Tests
- Survey to understand the social impact of art places on community

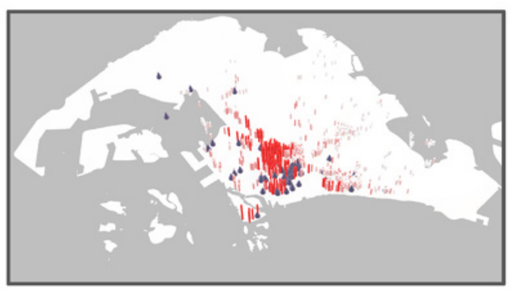


Fig 8: 3D Map of Property Prices (red lines) and the Art Places (black cone)

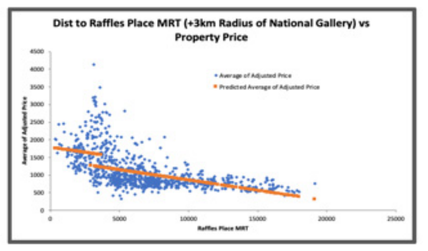
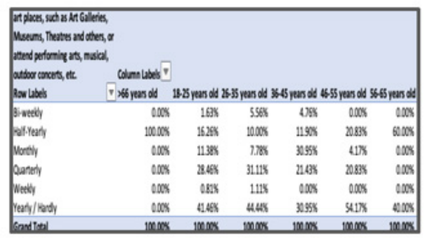


Fig 6: Two-Variable Regression: removing confounding variable such as distance to CBD and proves that distance to important Art Places, such as National Gallery has positive impact on property prices.



art places, such as Art Galleries, Museums, Theatres and others, or attend performing arts, musical, outdoor concerts, etc.	Column Labels					
Row Labels	>66 years old	18-25 years old	26-35 years old	36-45 years old	46-55 years old	56-65 years old
Bi-weekly	0.00%	1.63%	5.56%	4.76%	0.00%	0.00%
Half-Yearly	100.00%	16.26%	10.00%	11.90%	20.83%	60.00%
Monthly	0.00%	11.38%	7.78%	30.95%	4.17%	0.00%
Quarterly	0.00%	28.46%	31.11%	21.43%	20.83%	0.00%
Weekly	0.00%	0.81%	1.11%	0.00%	0.00%	0.00%
Yearly / Hardly	0.00%	41.46%	44.44%	30.95%	54.17%	40.00%
Grand Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Fig 7: Example of survey analysis: pivot table: age vs. Frequency of visit

Realize

3D Mapping of Art Places vs Property Prices

Suggestions to art places planning in Singapore

- There should be a **decentralizations** of art places as the analysis shows art places has positive influence on property prices &community
- There should be more **public involvement** in art planning process as it could improve the willingness of public participation and the frequency

- Art places has positive influence on property prices &community.
- Distance to art places affect the frequency of visiting art places.

Qualitative Analysis on the survey with approximately 300 respondents:

- The household income has no significant impact on frequency of visiting art places.
- proximity to art places has positive impact on frequency.
- The mid-age group (36-45y) with children is the group visit art places most frequently.
- The frequency has positive correlation to perception of the importance of art places.
- Public participation is important to art planning process.

SCAN ME

Scan for the full survey questions

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