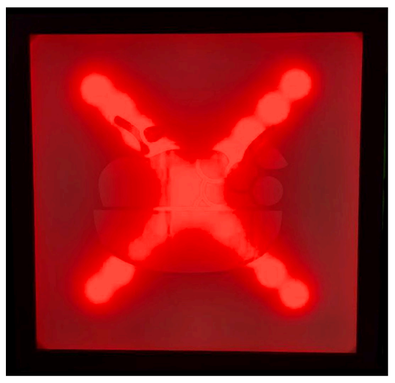

Warning On Wall

A Robotic Wall Art Safety Installation

THE TEAM

Syarifuddin Azhar Bin Rosli 1005187
Thang Li Wen, Elena 1006092
Soh Zhi Ying 1006359
Mohd Al-Ahda 1006028

COURSE MENTORS

01.101 Technologies for Sustainable Global Health
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Instructor: Dr Shireen Goh
Industry Partner: EGH Smart Systems Planning Team

IDENTIFICATION

Patients at risk of falls are particularly vulnerable due to health factors such as balance issues and muscle weakness. In hospitals, they are instructed to call for nurse assistance before attempting to move from their beds. However, some may still try to leave independently, which poses significant safety risks and can worsen their injuries.To address this urgent issue, SingHealth is partnering with SUTD to design a low-tech, art-centric solution that minimises technology fatigue in an already tech-heavy environment. The goal is to find a way to distract fall-risk patients for at least five seconds, allowing nurses sufficient time to intervene and prevent falls.

Feasibility
While the project focuses on an art-centric solution, it falls outside the expertise of the engineering-trained team members, so functionality will take precedence over artistic features.

Existing Solutions
Floor mats and inflatable vests primarily aim to minimise fall injuries rather than prevent them

Stakeholders
The goal is to create a solution that benefits both nurses and patients at risk of falls.

Market Size
The global market for medical technology was valued at USD518 million in 2023, with the fall detection and prevention sector at USD477 million and expected to grow at a compound annual rate of 7.66% by 2030.

Clinical Observations at Healthcare Living Lab (HLL)

The engineers stationed at HLL identified common scenarios that prompt patients at risk of falls to leave their beds, such as the need to relieve themselves without calling for assistance from a nurse. They noted that these incidents frequently **occur at night** when **nursing staff are limited**. Therefore, the proposed solution must take this time variance into account.

The visit at HLL also provided valuable insights into the layout of the hospital ward where the device will be installed. The device must be designed to accommodate an increasing number of incoming smart devices while **minimising its own footprint**. Additionally, it should **not obstruct or interfere with the workflow** or standard operations of the nursing staff, particularly during emergencies.

NEED CRITERIAS

Must-Haves	Good-to-Haves
Production cost < $100	Connected to digital twin
Cannot be battery-powered	Connected to nurse call system
Captures attention without startling patients	Wall-mounted
Easy to maintain for cleaning and sterilisation	Blend into surroundings
Ease of Mass Manufacturing	Language Neutrality
Low-tech	

IDEATION

Concept Generation + Prototype Iterations

Utilised guided brainstorming techniques to generate a vast amount of ideas.

Idea #1 - Rustling Lalang

Lalang on the wall starts rustling once the patient getting out of the bed is detected.
At night, lights would be turned on as well to attract greater attention.

Feedback:
Out of patient's field of vision, and rustling is too soft to attract attention.

Idea #2 - Projection onto the bed

A concealed projector is placed on the wall. Once activated, images will be projected to the base of the patient's bed.

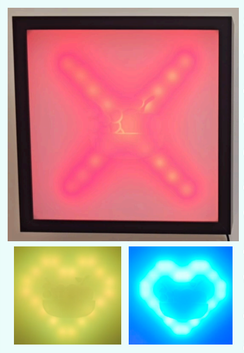
Feedback:
Eerie sound and patient sitting position blocks projection rays.

Idea #3 - Floodlight on floor

The floodlights will cast red lights onto the floor once activated, indicating to the patient that it is dangerous to leave the bed.

Feedback:
Too glaring, concerns of affecting surrounding beds, may scare patients at night, and set-up takes up too much space.

Idea #4 - Warning on Wall WOW



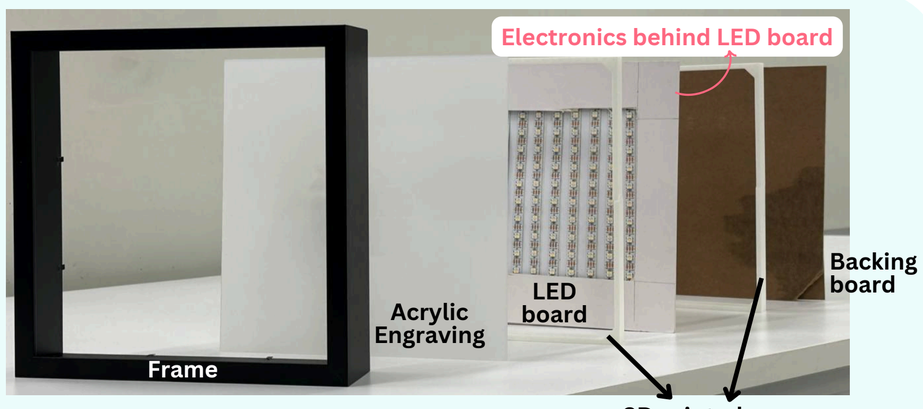
Compact Design where images such as fruits are engraved on the outer acrylic. When activated, a red "X" will be displayed and beeping sounds will be played, to attract the patient's attention.

Concept Filtering & Selection

For concept selection, we utilised AI (ChatGPT) and peer evaluation to identify the advantages and limitations of each idea.

WOW was selected due to it's compactness, it's ability to attract attention without the need for spoken language, and it's customisability as the design can be fine-tuned for a wide demographic of people and disabilities.

OUR PROTOTYPE

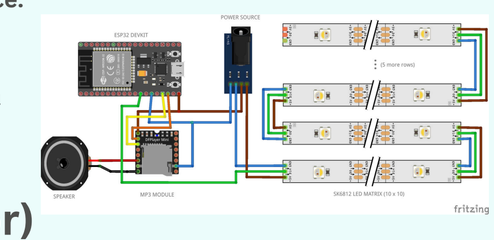


Design Features

Visuals	Fruit Image	Symbol of healing and vitality.
	'X' symbol	The "X" symbol was chosen because it is a universal stop indicator that can be easily understood and interpreted by all demographics. Furthermore, the image requires low cognitive effort, thus allowing for quick interpretation.
	Colour	Red was selected as it is generally understood as an "alert" colour and thus effectively draws attention to it.
Audio	Beeping Sounds	Beeping tones are language neutral and non-disruptive.
	Volume	The volume was fine-tuned to be audible solely to the patient at risk of fall who is about to leave the bed, and not, if not minimally, be audible to the neighbouring beds.
	Frequency	The frequency was curated to fall within the audible range of elderlies, as well as the operating range of the speakers of the device.

Electronic Features

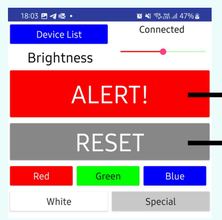
The entire system draws **7.5W**. The **ESP32** connects to the digital twin via **Bluetooth Low Energy (BLE)**, hence enabling wireless triggering of the WOW system via the EGH Digital Twin System.



Application Feature (Digital Twin Mirror)

Connect to WOW device

Locate WOW device in list



Device connected, WOW ready to use

User Journey

Engineers

Visual Cues for Engineers:

Switch on power → Device On: LED turns green

Connect System via bluetooth → Connected: LEDs turn blue

System ready for trigger from Digital Twin → Standby Mode: No LEDs on

Nurse

Respond to alert → Attend to patient → Press reset button to restart system for trigger

Cost Breakdown

MP3 Module with Speaker **$17**	ESP32 DEVKIT **$4.07**	Jumper Wire **$1.38**	Laser Engraving **$10**
Universal AC/DC Adapter **$18.30**	SK6812 2M RGBW LED Strip **$5**	Power Supply Connector **$5**	
3mm Acrylic **$4**	Jumper Wire **$1.38**	16GB Mico SD Card **$10.50**	Cardboard **$2.50**
3D Printed Spacers (with Power Usage) **$1.81**	Laser Engraving **$10**	IKEA Photo Frame **$9**	

Total Product Cost **$88.55**

CONCLUSION

Functionality Testing

Data Speed: Measured the time from which the mock Digital Twin was activated till the time the audio and visual would be played
Volume: Measured the decibel level when the audio from the speakers are played at max volume. The decibel meter was placed approximately 2m from the source
Brightness: Measured the brightness of the projection reflecting off a smooth white surface in a dark room and the ambient brightness levels in an artificially-lit indoor room

Insights gained

Data Speed: Average data speed: 1.392s
Volume: Average Maximum Volume: 70 dB
Brightness:
Brightness of Projection(lights OFF): 22 lux
Brightness of Test Room (no projection): 24 lux
Brightness of projection under room light : 57 lux

Success

- WOW meets all essential requirements and includes desirable features
- Compact, enclosed design ensures easy cleaning and sanitisation
- Powered by mains and wall-mountable for convenience
- Easily replicable with a manufacturing cost of $88.55
- Alert mechanism is language-independent, ensuring universal accessibility

User Testing

Test Venue
SUTD Hostel: Ease of bringing in test subjects, where most of them were students
HLL: Testing with Engineers and Nurses

Briefing of Participants

- Participants were briefed on the purpose of the project
- They were tasked to emulate the user profile of a fall-risk elderly who wants to get out of the bed at night to use the washroom
- No further context on the interventions were provided

Data Collection

- Prototype performance was observed to assess functionality
- Participant thoughts on how effective they thought the proposed solution was in drawing their attention

Insights gained

- Patients with hearing impairments may miss the alert, suggesting alternative notification methods are needed
- The solution works best for patients with some mobility; those with limited movement may not respond as intended
- Engraving on the device was well-received for its visual appeal
- Device's sound was found engaging and attractive
- The "X" symbol effectively prompts patients to freeze, showing potential as a strong visual cue for fall prevention