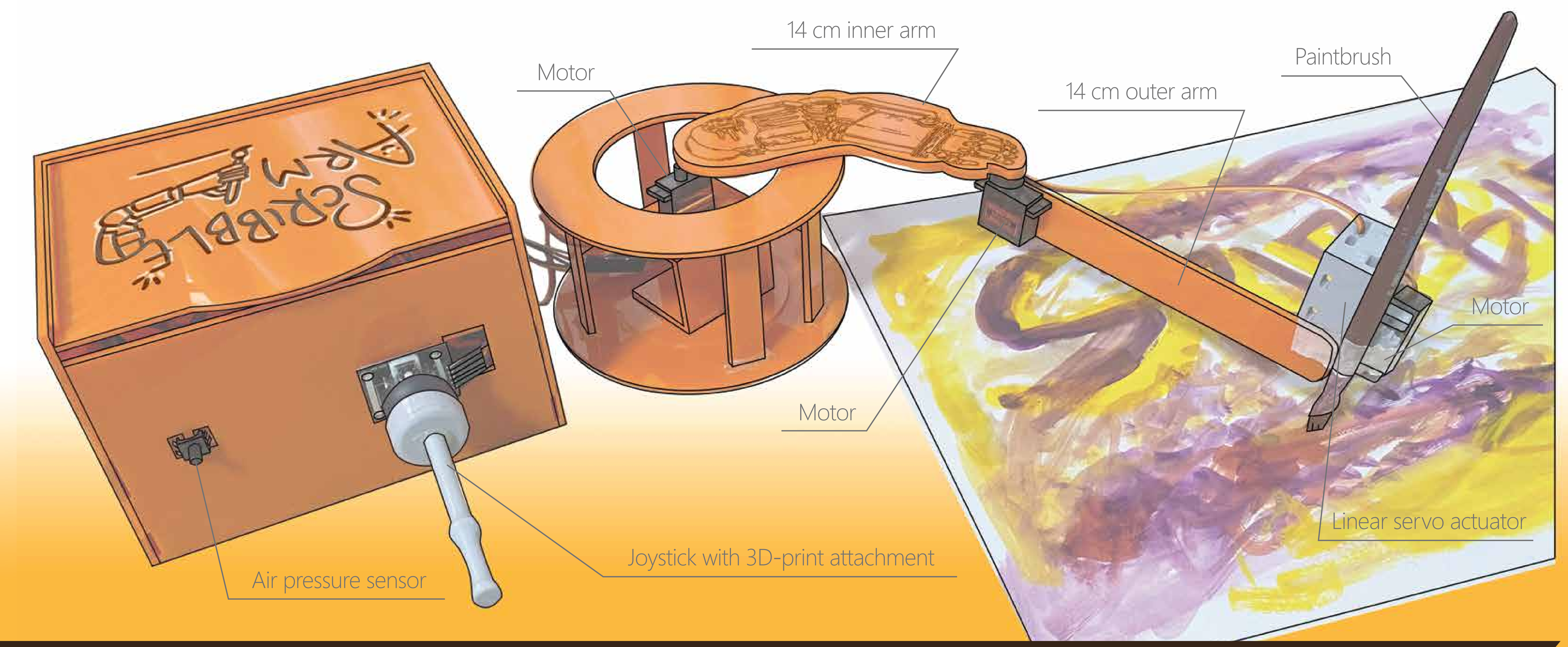

Scribble Arm — Extending the Joy of Creating Art

CP03 GROUP 9

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PROBLEM STATEMENT

The quest to create meaning and the desire to express ourselves are intrinsic to our existence as humans. Art is an important tool for self-expression and is frequently used in art therapy for individuals to release negative emotions and cultivate mental well-being. However, due to shortcomings of current prostheses for upper limb amputees in (a) the interfaces adopted for controlling the prosthesis, and (b) the lack of force or tactile feedback, these users have reduced hand grasp capabilities and might find art forms such as painting to be challenging and inaccessible.

Hence, how might we empower individuals who have limited arm mobility in artwork creation?

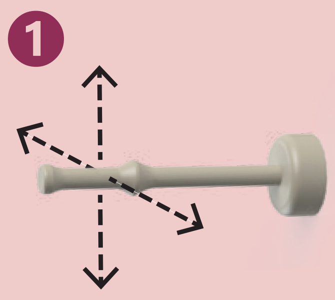
OBJECTIVES

We aim to design and build the following:

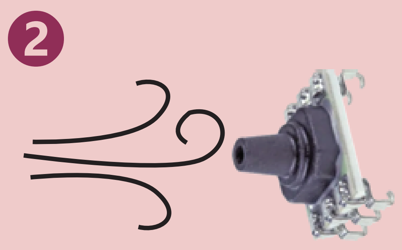
- Selective Compliance Assembly Robot Arm (SCARA) plotter
- Retractable paintbrush holder that allows user to move the paintbrush towards / away from the canvas
- Controller suitable for users that cannot properly mobilize their arms

HOW IT WORKS

INPUT

1 

3D-printed joystick attachment → allows user to control joystick using tongue → joystick movement as input

2 

Pressure sensor → allows user to blow on pressure sensor → air flow as input

DATA PROCESSING

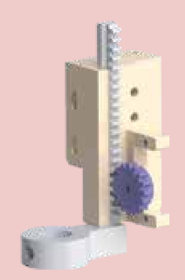
1 Movement → change in resistance of 2 ***potentiometers*** (for X and Y axes) within joystick → change in ***voltage*** which serves as analog input → ***analog-to-digital converter*** converts voltage readings to output readings

2 Air flow → heat and temperature sensing elements provide rapid response to air flow → deliver ***voltage*** proportional to air flow detected → ***analog-to-digital converter*** converts voltage readings to output readings (pressure and temperature)

OUTPUT

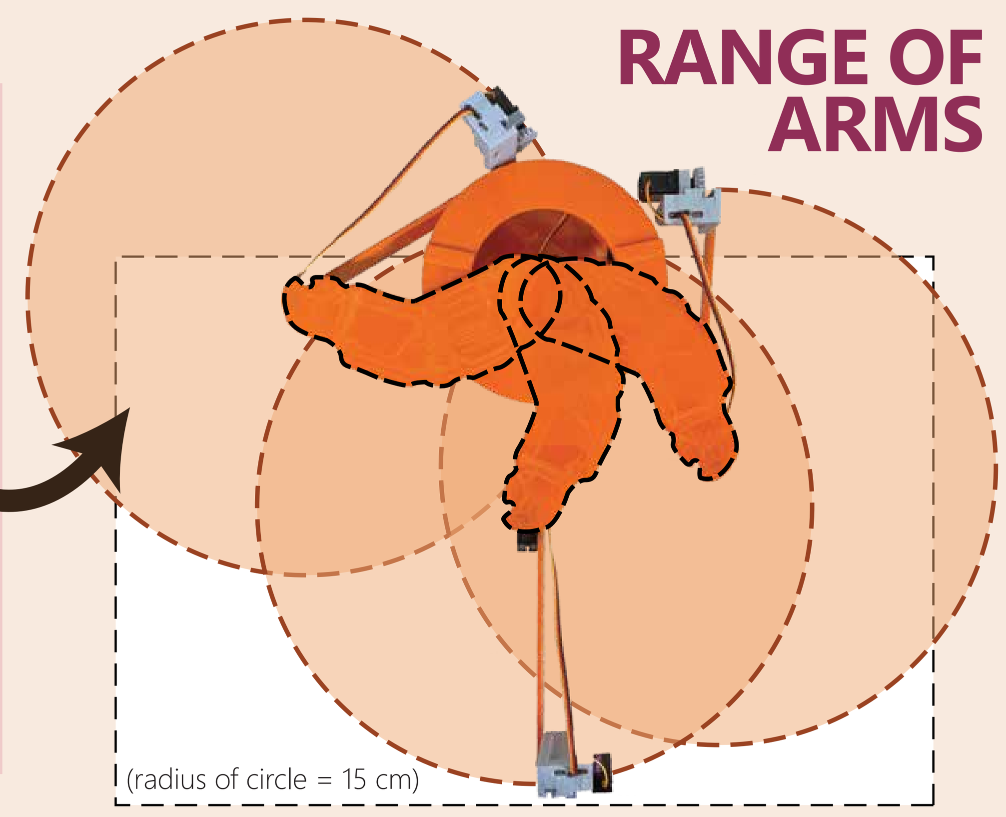
1 

Mapping of joystick's Cartesian coordinates into polar coordinates between shoulder and elbow joints of the robot's arms → move 2 servo motors → move inner and outer arms

2 

Pressure sensor → either clockwise or anti-clockwise rotation of motor → turn gear → pusher moves up or down → paintbrush can be lifted off or be placed onto canvas

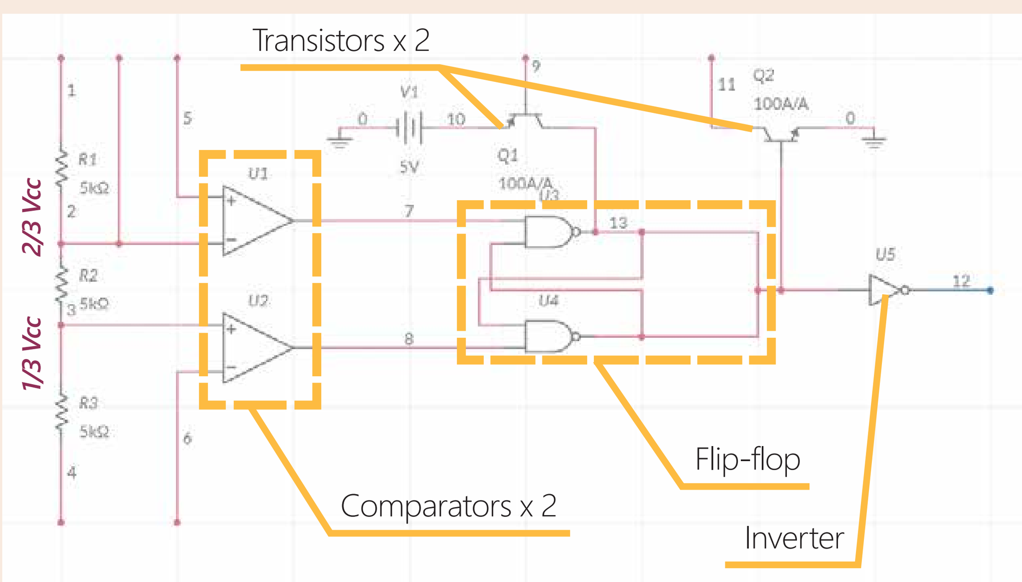
RANGE OF ARMS



FULL-SCALE MODEL

CIRCUITS

555 TIMER

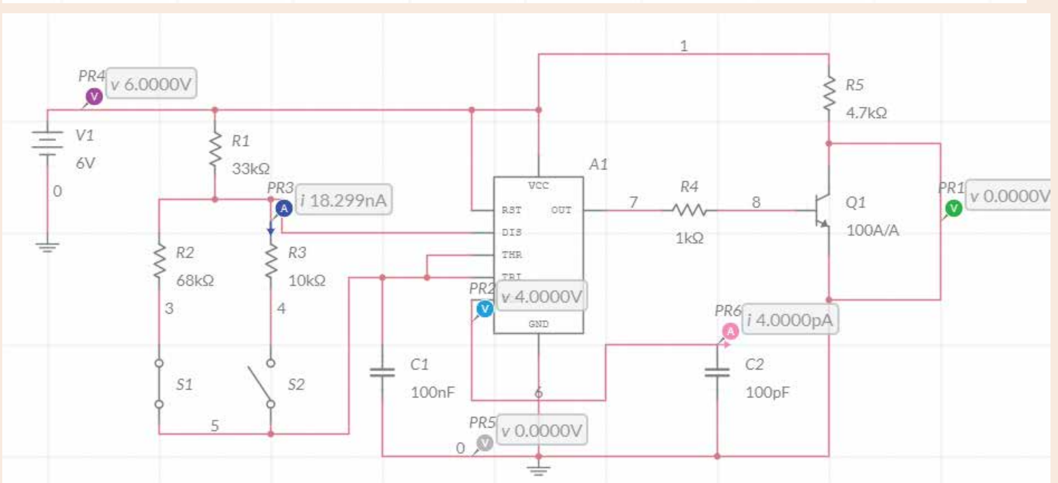


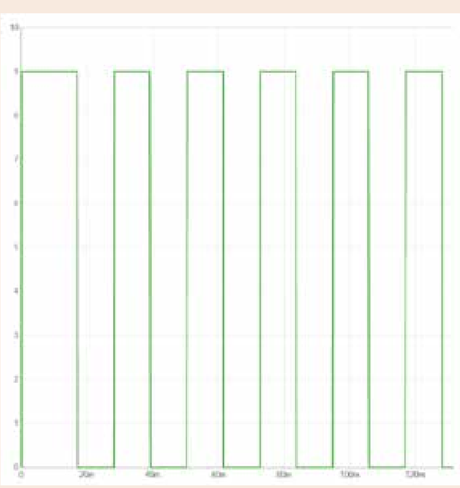
INPUTS		OUTPUTS		
Pin 6	Pin 2	R	S	Q
0	0	0	1	0
0	1	0	0	0
1	1	1	0	1
1	0	1	1	Invalid

555 timer concepts: ***Voltage divider***, ***capacitor***, ***comparator***, ***transistor***

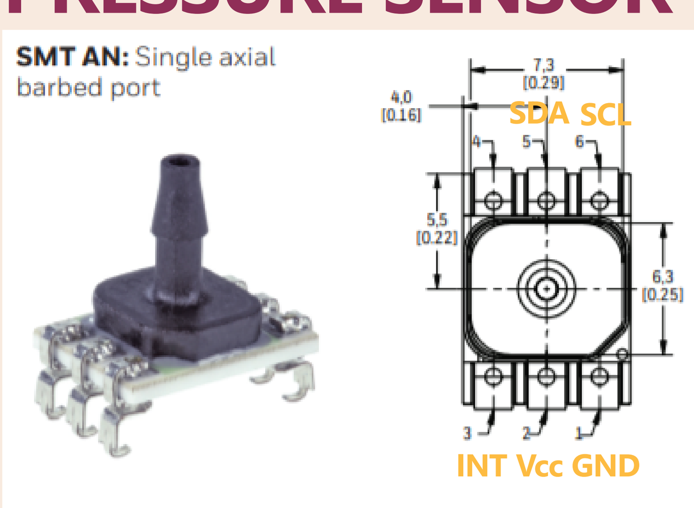
Using a 555 timer, we can generate ***pulse-width modulated signal*** → control the 2 servo motors connected to the inner and outer arms

- Pin 2 and Pin 6 shorted together → astable mode
- Closing or opening different switches → different ratios of resistor values → different rates of discharging for capacitors → different duty cycles → rotate in different directions
- Switch 1: Anti-clockwise rotation
- Swtich 2: Clockwise rotation





PRESSURE SENSOR



Pressure sensor varies voltage at output

→ Connecting the pressure sensor to a ***MOSFET voltage- controlled switch*** combined with the ***555 timer*** circuit shown above

→ Pressure sensor can be used to control the clockwise and anti-clockwise rotation of the servo motor

→ Servo motor rotates to move paintbrush towards or away from canvas

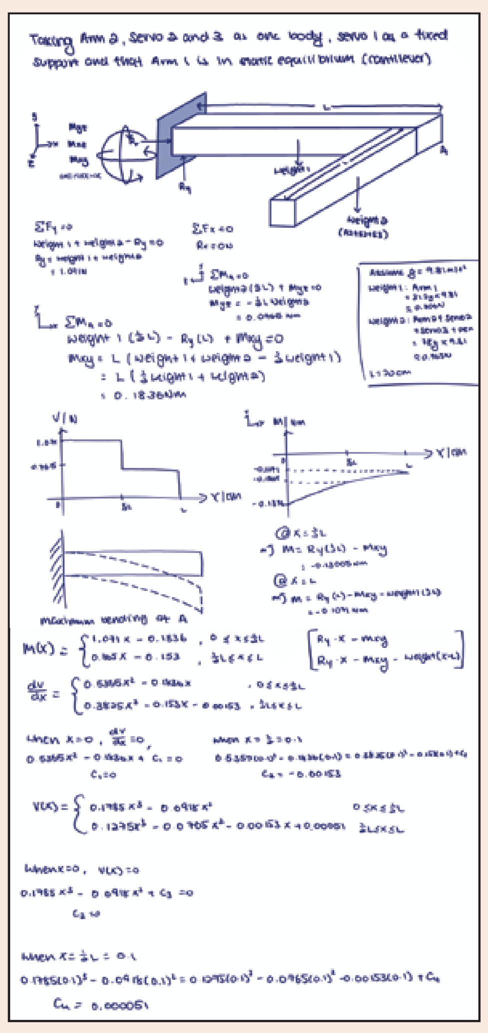
STRUCTURES

Movement SCARA robot's arms → dynamic equilibrium constantly established, destroyed, and then re-established

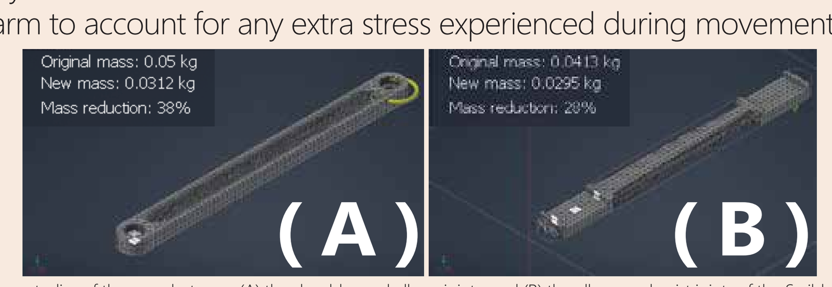
Constructing FBD to represent forces and torques acting on each arm along all three axes is exceedingly difficult due to:
(1) a large number of unknown support reactions, and
(2) insufficient equilibrium equations

Hence, we assume that the arm linking the shoulder and elbow joints of the robot can be modelled as a static cantilever beam

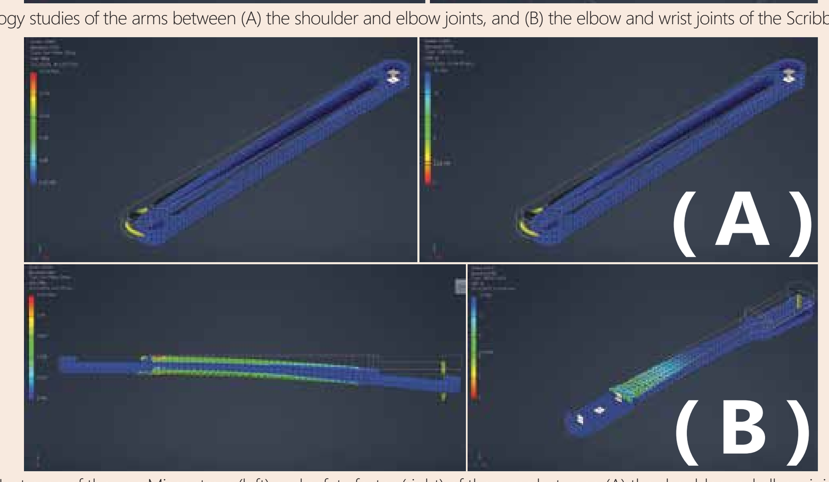
The centre of mass of the mini servos at the elbow and wrist joints and the arm linking said joints is then applied a certain distance away from the elbow joint and is maximum when the angle between the arms is 90°



Simplified FBD cannot ensure rigour in our structural analyses of full-scale model → conduct topology studies to optimise shape of each arm of robot
Thereafter, finite element analyses (FEAs) were run on these optimised structures to calculate the von Mises stress under complex loading conditions that bore a closer resemblance to what will be experienced
A safety factor of 2 was set as the minimum threshold for the structural integrity of each arm to account for any extra stress experienced during movement of the arms



Topology studies of the arms between (A) the shoulder and elbow joints, and (B) the elbow and wrist joints of the Scribble Arm.



Heat map of the von Mises stress (left) and safety factor (right) of the arms between (A) the shoulder and elbow joints, and (B) the elbow and wrist joints.

CONCLUSION AND FUTURE WORK

The full scale-model consists of:
- Arm linking shoulder and elbow joints: Laser cut 10 mm-thick sheet of cast acrylic and drill a counterbore M3 through-hole into both ends (safety factor of 2.53)
- Arm linking elbow and wrist joints: 3D printed using ABS due to its slightly more complex nature (safety factor of 6.53)
- 7.4 V high-speed mini servos (Savox SV-1250MG): Provide a torque of 8.0 kg/cm at a speed of 0.095 s/60°, weighing 29.5 g each

Improvements:
- Design structure such that robot can be used on an upright canvas
- Improve accuracy of arms in painting
- Make controller more compact
- Use one pressure sensor instead of two to control the linear servo actuator
- Add mechanism to let robot easily change paint colour

Special thanks to our CnE and SnM professors for their patience and guidance! :)