# Regeneratus

An adaptive, regenerative protection suit for all armed forces personnel

By: Geo Raguraman

# Problem Statement and Solution

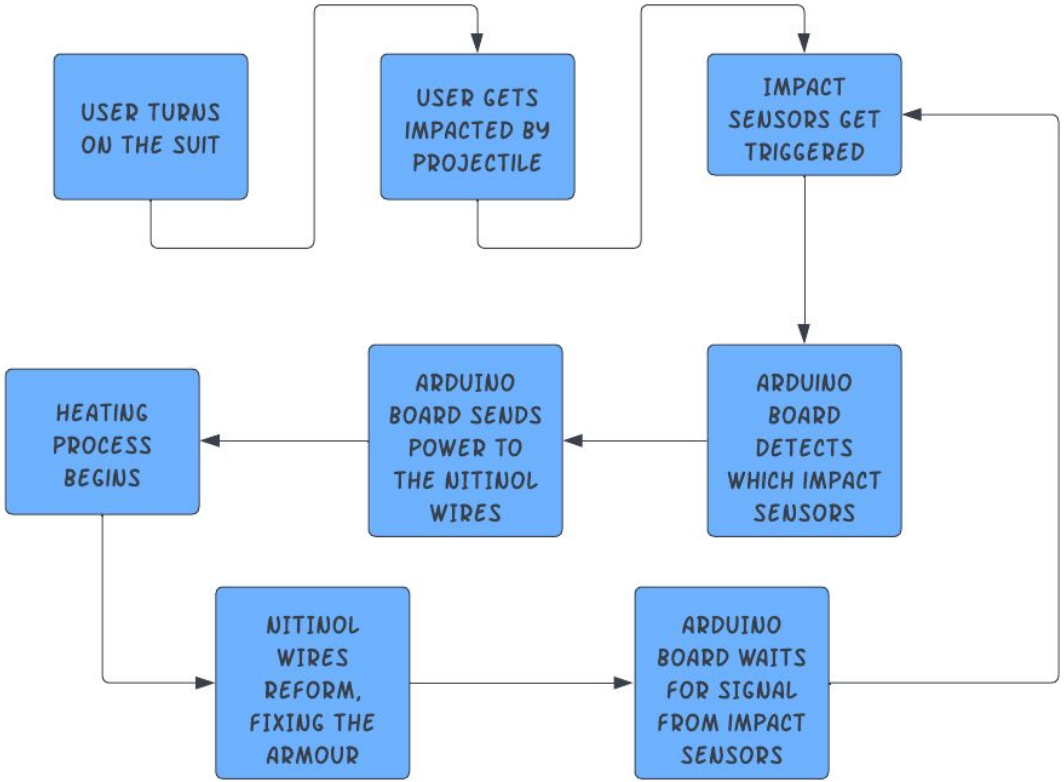
Behind armor blunt trauma (BABT) is the injury caused by the kinetic energy of the projectile being absorbed by the body armor and transmitted to the person's body, resulting in trauma. This type of injury can be severe or even fatal, depending on the type and velocity of the projectile, as well as the location and extent of the injury. BABT causes various internal injuries and may require medical attention.

Our solution to this problem is design a suit that implements a memory metal: Nitinol. Nitinol exhibits the shape memory effect because of the way the atoms are arranged in its crystal structure, and when heated it reforms back to its original shape. Integrating nitinol wire with other materials such as kevlar and carbon fiber will make the suit even stronger, with its ability to reform after impact

# Hypothesis

If armed forces and law enforcement personnel use the regeneratus suit, then they will not suffer from BABT due to the caving in of the armour, and not to replace their armour because of the shape memory properties Nitinol exhibits to reform their suit.

# Process Flow

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# Prototype Build Procedure

**Building the Circuit 1**

a. Starting the Electrical Connection between the Arduino and the Breadboard
   i. GND and 5V
      1. Run a  jumper wire from the 5v port from the arduino and place it A1
      2. Run a jumper wire from the GND port from the arduino and place it into B1

b. Building 6 Nitinol Wire plus Relay
   i. Vibration Sensor 1
      1. Place the GND from the Impact Sensor into B2, SIGNAL pin from the Impact Sensor into DIgital Pin 11, and wire the VCC pin from the UDS into A2
   ii. Relay
      1. Place the GND from the Relay into B4, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A4
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires
   iii. Relay
      1. Place the GND from the Relay into B6, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A6
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires
   iv. Relay
      1. Place the GND from the Relay into B8, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A8
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires

**Building the Circuit 2**

a. Starting the Electrical Connection between the Arduino and the Breadboard
   i. GND and 5V
      1. Run a  jumper wire from the 5v port from the arduino and place it A1
      2. Run a jumper wire from the GND port from the arduino and place it into B1

b. Building 6 Nitinol Wire plus Relay
   i. Vibration Sensor 1
      1. Place the GND from the Impact Sensor into B2, SIGNAL pin from the Impact Sensor into DIgital Pin 11, and wire the VCC pin from the UDS into A2
   ii. Relay
      1. Place the GND from the Relay into B4, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A4
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires
   iii. Relay
      1. Place the GND from the Relay into B6, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A6
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires
   iv. Relay
      1. Place the GND from the Relay into B8, wire the TRIG pin from the Relay into Digital Pin and wire the VCC pin from the Relay into A8
      2. Wire the NO to the positive end of the battery, and the Control pin to the negative lead controlling a looping circuit through the nitinol wires

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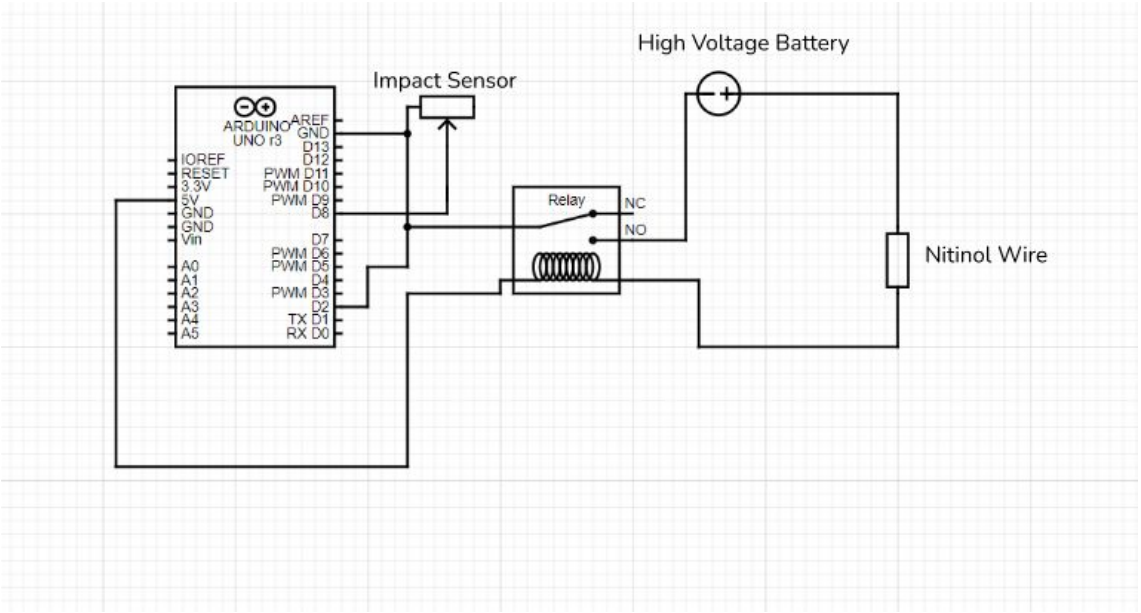
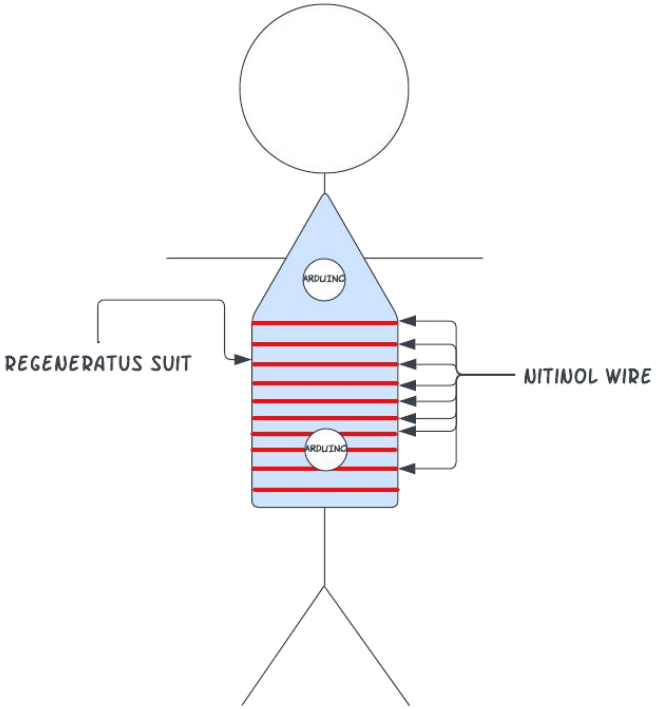
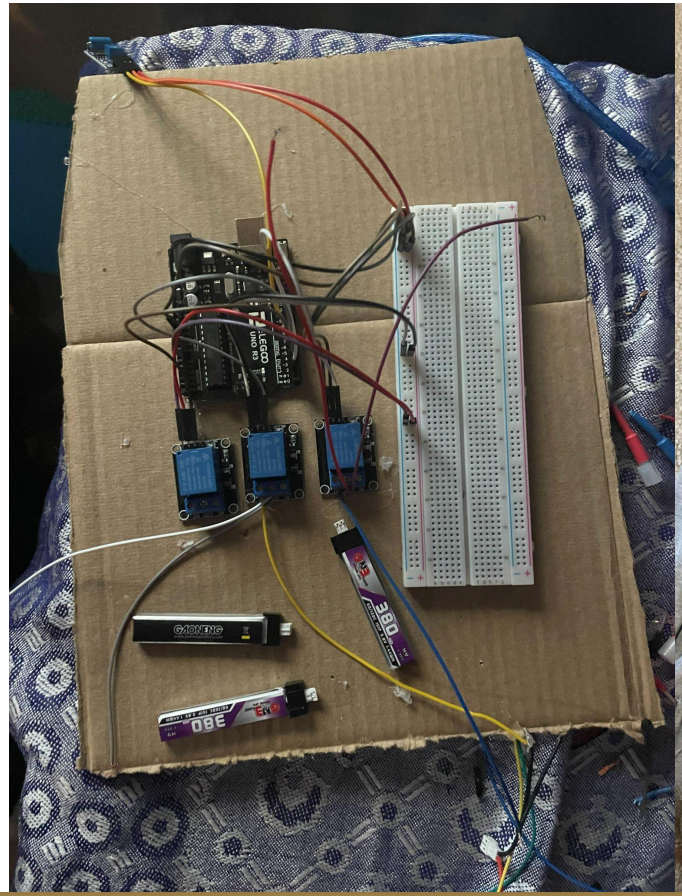
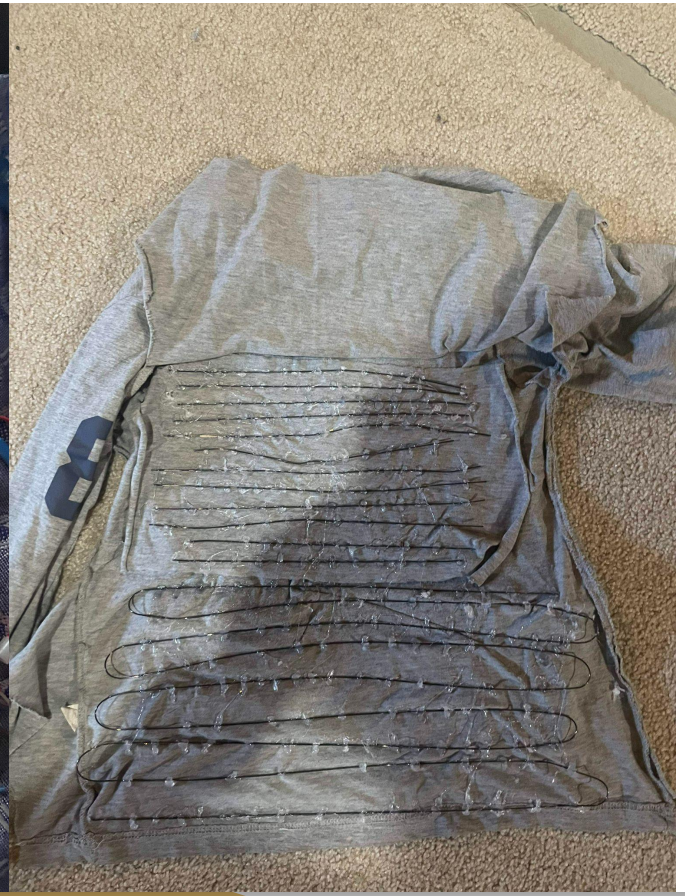
# Circuit Diagram and Visual Schematic



# Prototype 1.0



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# Data Collection

| Deformation of Suit (in) | Time taken to reform suit (s) | | | | | Average (s) |
|---|---|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | Trial 4 | Trial 5 | |
| **1 in** | 1.43 | 1.71 | 1.48 | 1.45 | 1.53 | 1.52 |
| **2 in** | 2.66 | 2.52 | 2.62 | 2.57 | 2.59 | 2.592 |
| **3 in** | 7.46 | 7.28 | 7.15 | 7.83 | 7.89 | 7.522 |
| **4 in** | 9.16 | 9.21 | 9.07 | 9.18 | 9.17 | 9.158 |
| **5 in** | 13.46 | 12.98 | 12.99 | 13.32 | 13.19 | 13.188 |

# Data Collection 2.0

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| Nerf Gun firing a RIVAL bullet | Time taken to fully reform suit (s) | | | Avg Time (s) |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| 5 ft | 1.31 | 1.46 | 1.58 | 1.45 |
| 6 ft | 1.27 | 1.37 | 1.63 | 1.423333333 |
| 7 ft | 1.53 | 1.3 | 1.29 | 1.373333333 |

| Punch Level | Time taken to fully reform suit (s) | | | Avg Time (s) |
|---|---|---|---|---|
| | Trial 1 | Trial 2 | Trial 3 | |
| Light | 10.71 | 10.03 | 9.67 | 10.13666667 |
| Medium | 12.69 | 13.23 | 13.88 | 13.26666667 |
| Hard | 15.79 | 15.9 | 15.21 | 15.63333333 |

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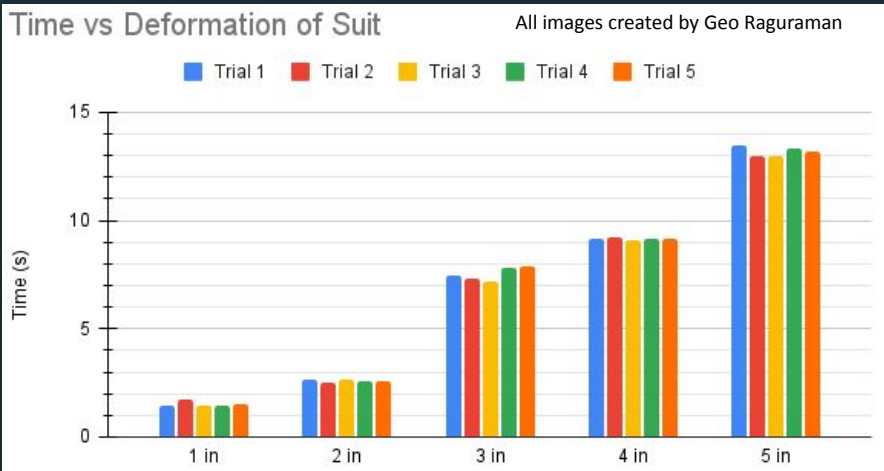
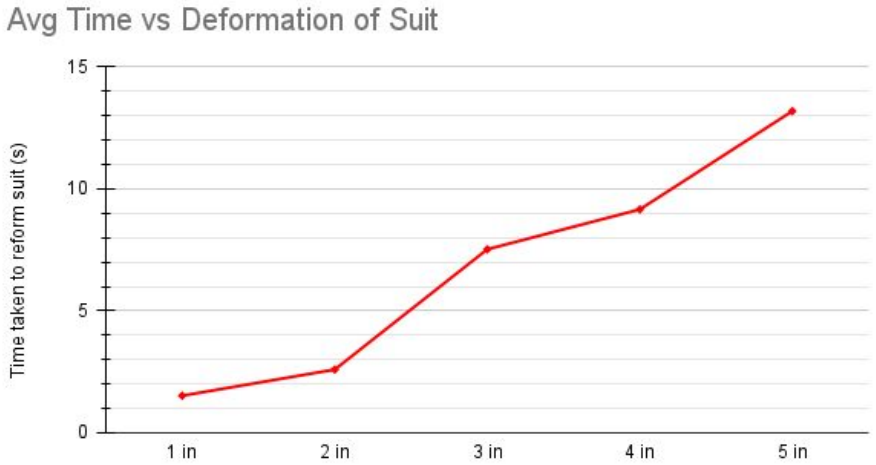
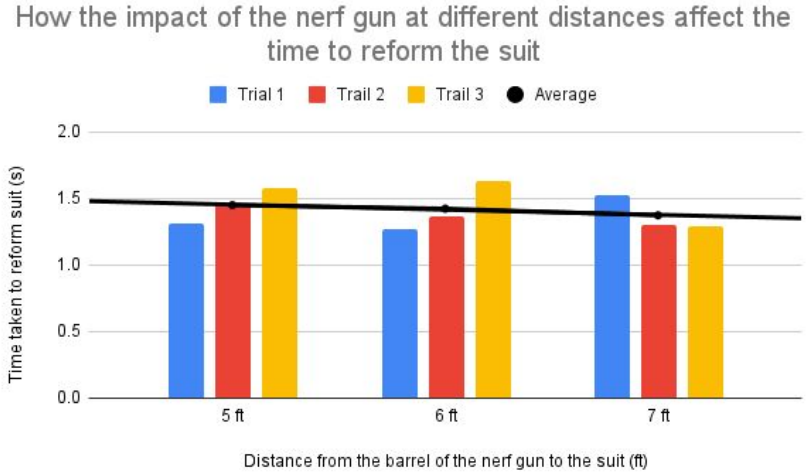
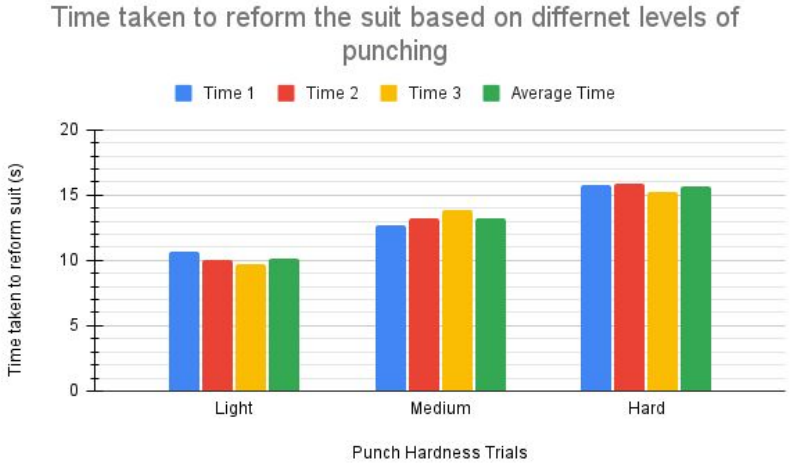


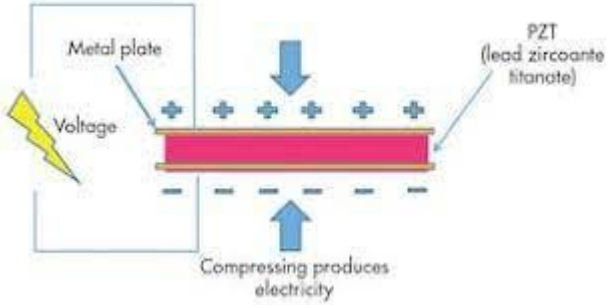



# Conclusion and Future Research

When a piezoelectric material is subjected to mechanical stress or deformation, its atoms become displaced from their equilibrium positions, creating a net electric charge within the material. This charge can be measured as a voltage across the material, or can be used to generate an electric field. Using this concept of piezoelectric sensors the mechanical stress caused by the impact of the any projectile towards the suit can be reused for electrical energy to power the circuit as well.



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