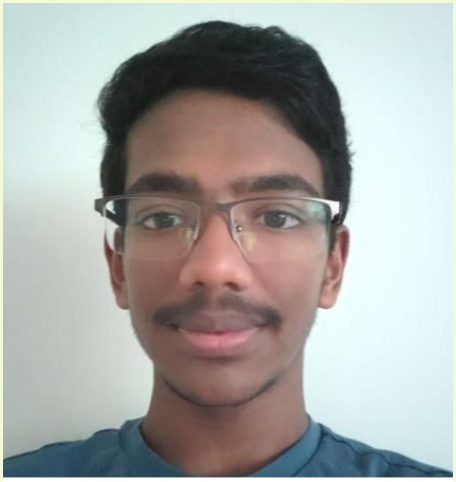
TrustFall

A device to protect the hips in the event of a fall

Developed by the ButterCats

Our Motivation

Our team is motivated by our shared goal of improving people's safety, well-being, and quality of life.

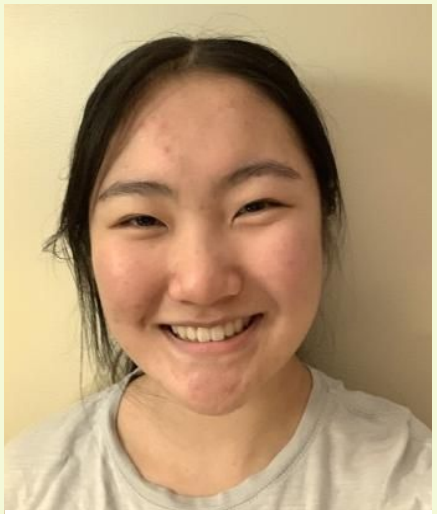


CEO Venkatraman Varatharajan

After extensive research, we identified hip injuries due to falls as a major health concern for older adults. Thus, we developed TrustFall in order to address the need for hip protectors that are safe, comfortable, and unobtrusive to daily life.

CMO Shuling Lin

CTO Sumanth Sura



CIO Emily Wang

Our Motivation

Below is some of the information that drove us to develop TrustFall. We hope to not only develop a protective device but also spread awareness of hip injuries and their potential causes, risk factors, consequences, and preventative measures.

- Falls are a common cause of injury among adults.
  - **35**% of those over **65** experience a significant fall (WebMD Editorial Contributors, n.d.).
  - **45%** of those over **70** experience a significant fall (WebMD Editorial Contributors, n.d.).
- Over **95%** of hip injuries are caused by falling (CDC, 2020).
- Hip fractures result in **300,000** hospitalizations each year (CDC, 2020).
- Recovery time increases with age.
- Women experience **75%** of all hip fractures due to factors such as falling more often and osteoporosis (CDC, 2020).
- Patients with osteopenia, at least two risk factors of osteoporosis, or a history of any fracture beyond the age of 50 are at **higher risk** of hip fracture (Quigley & Tarbert, 2021).
- A past hip fracture increases risk of subsequent hip fracture by **150%** (Quigley & Tarbert, 2021).
- Hip fractures increase mortality and limit independence, thus impacting **quality of life** in the long term (de Bot et al., 2020).
- Other hip protectors are available, such as polyurethane hip pads (Quigley & Tarbert, 2021).
- Most elders do not used hip protectors, often due to a bulky or uncomfortable design or concerns about social stigma (Quigley & Tarbert, 2021).

TrustFall: The Prototype

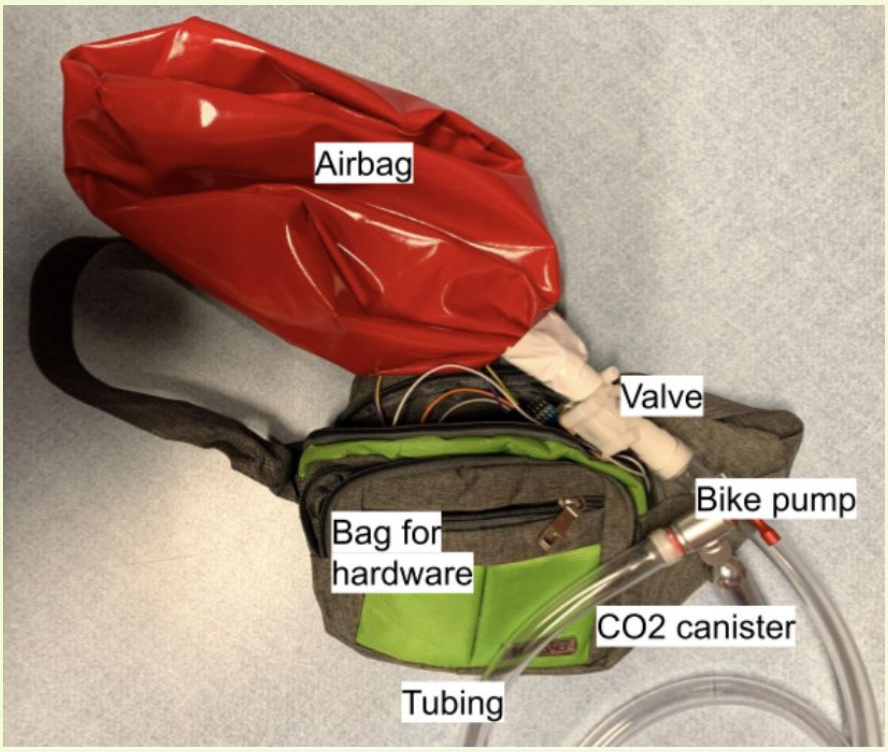


Figure 1: ***Uncovered view of TrustFall***. The TrustFall device is pictured with the parts that allow the device to activate

The entire device will sit at the client's waist. Iif the Arduino receives data from the accelerometer that the machine learning algorithm registers as a fall, the power controller sends 12V to the valves, which will then open and allow compressed CO_2 to flow into the airbags to protect the user before they hit the ground.

The actual final prototype of TrustFall consists of a device that is completely covered by fabric in order to draw less attention to it. For testing and viewing purposes this prototype only has fabric over one hip. For the same reason, the center is left unobstructed.

Figure 2: ***TrustFall while on an individual and half of it covered***. This image contains the TrustFall device where one half of it is covered by fabric. The airbag on the other hip is unobstructed.

TrustFall: The Process

Materials: 2 ZE4F18012V water solenoid valves (Ximimark valve), 1 Arduino Uno, 1 GY-521 MPU6050 3-axis gyroscope and accelerometer IMU, 2 threaded 16g CO_2 cartridges, 0.25 linear yard 58" 400 D. heat sealable coated packcloth, 1 split wire, 8 male to female wires, 10’ clear vinyl tubing, 1 fanny pack, 2 CO_2 bike tire inflators

Airbag:

1. Cut the fabric as shown in the templates:
2. Heat seal the fabric inside out, with pattern B placed on each side of pattern A, oriented in the same way as shown.
3. Place the dome made in step 2 over patten C and heat seal, inside out.
4. Invert the airbag.
5. Repeat with remaining pieces

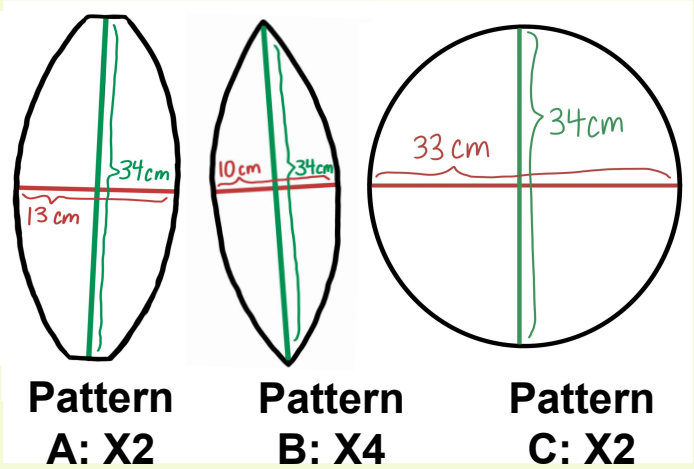


Figure 3: ***Patterns for airbag***. The three patterns that are needed to create the airbag.

Machine Learning Model:

1. Connect the Arduino to the accelerometer
2. Collect fall data using the Arduino for training and testing the model
3. Group Arduino readings in small groups and mark all readings a set time before impact
4. Train a neural network to take in the groups of readings and identify the marked groups

Our code is available for use at:
https://github.com/TrustFall-AT/activation-algorithm

Putting it Together:

1. Cut the tubing into 2 19-inch pieces and 2 4-inch pieces.
2. Attach one end of the 4’’ tubing to the bike pump and the other end to the inlet port of the valve.
3. Attach one end of the 19’’ tubing to the exit port of the valve and seal the other end inside the airbag.
4. Attach the Arduino and accelerometer to the valve (*see following page*) and put them into the pouch of the belt

TrustFall: Circuitry

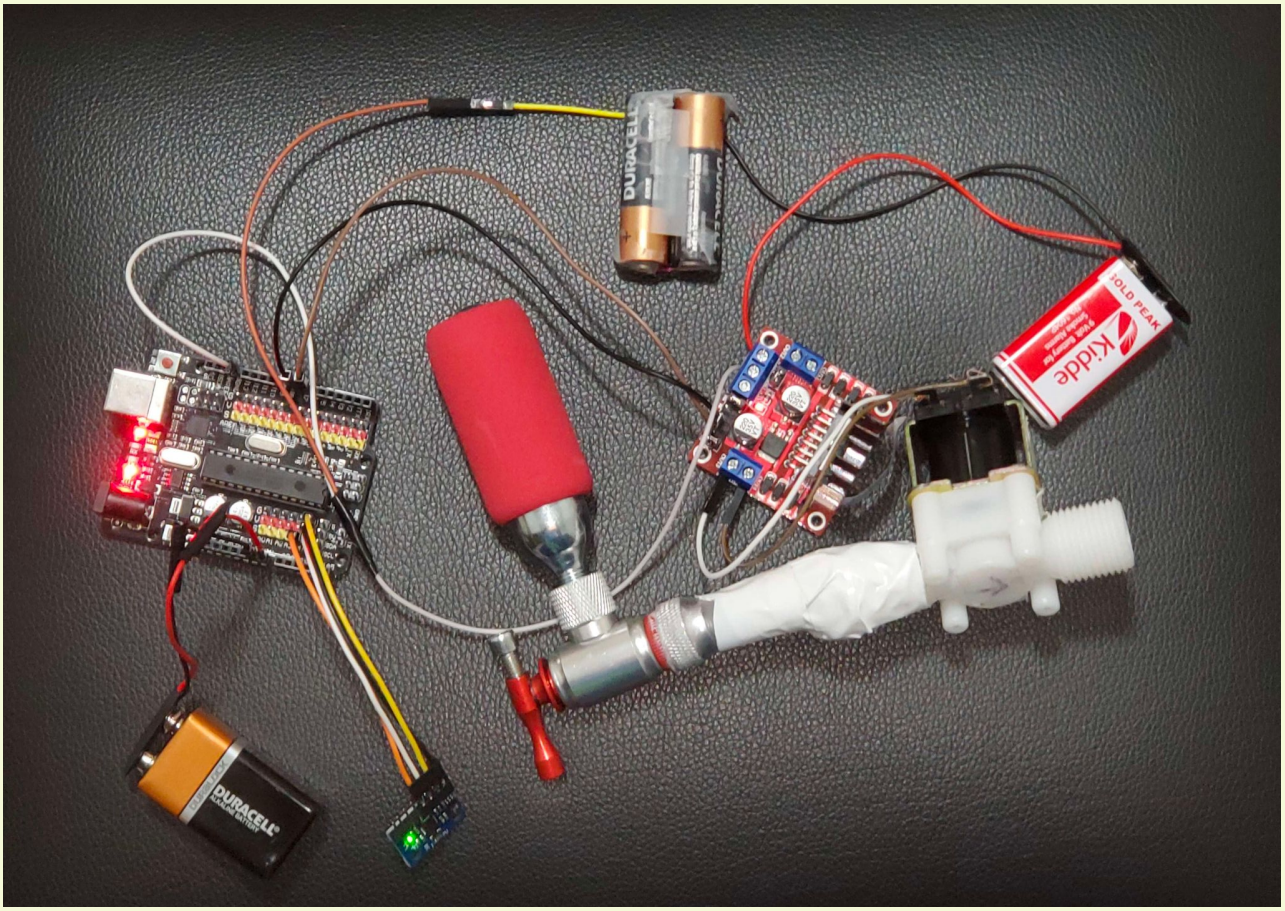


Figure 4: ***Arduino wiring***. Our device requires: Arduino, batteries, valve, accelerometer, CO_2, bike pump, Power Controller

Attaching the Circuitry

How to attach components to the Arduino: (the second ID refers to the terminal on the Arduino)

- 9V Battery
  - Positive to VIN
  - Negative to GROUND
- Accelerometer
  - GND to G
  - VCC to V
  - SCL to A5
  - SDA to A4
- Power Controller
  - IN4 to I7
  - IN3 to I8

How to attach additional components connected to Power Controller: (the second terminal written is on the Power Controller)

- Valve
  - One terminal to OUT3
  - Other terminal to OUT4
- Y junction wire
  - IGND on Arduino and positive end of 12V to GND on power controller
- 12V Battery
  - Positive end to +12V

Instruction Manual

1. Ensure the accelerometer, Arduino, and air canister are securely stored **within the pouch**. The accelerometer should be secured tightly.
2. Fasten the belt snugly around the waist, ensuring that the **pouch** is in **front** and the **airbags** are positioned above the **hips**.
3. Ensure that the circuit is **connected**, the bike inflator is **opened**, and the valve is initially **closed**.
4. Plug a battery for **each** battery snap for the device (see Figure 4)
5. Hit the **reset** button on the Arduino, and **wait** several seconds.
6. Feel safe while going about day-to-day activities
7. When not in use, remove batteries

Care and Maintenance

Our device requires minimal maintenance. However, to ensure the device is not damaged, proper setup, storage, and handling are required.

Setup

Refer to the instruction manual for setup instructions. Should the CO_2 canisters be depleted, they may be replaced with new canisters. If replacing the CO_2 canisters, proceed with caution. In order to be as safe as possible, keep the valve in the open position while replacing the canister. The ButterCats, the Massachusetts Academy of Math and Science, Worcester Polytechnic Institute, and any and all affiliated organizations may not be held liable for any damage, injury, or harm incurred as a result of replacing the canisters.

Storage

Store the device in a cool, dry place where it is not at risk of being put under pressure or dropped. When stored, turn the device off.

Handling

Do not shake of drop the device. Do not attempt to puncture or disassemble the device.

WARNING

Anyone handling or otherwise interacting with this device does so entirely **at their own risk**. The ButterCats, the Massachusetts Academy of Math and Science, Worcester Polytechnic Institute, and any and all affiliated organizations may **not be held liable** for any injury to, or the death of, any persons or for the damage to, or destruction of, any property, whether caused by the negligence of any degree of the ButterCats, the Massachusetts Academy of Math and Science, Worcester Polytechnic Institute, and any and all affiliated organizations.

This device is a **prototype** and is not intended to be used for protection or for life saving purposes. This device is not a toy. This device is not intended to be used outside of development and testing purposes by the ButterCats. This device contains highly pressurized gas, sharp materials, flammable materials, and live wires.

Citations

CDC. (2020, September 30). Hip Fractures Among Older Adults | Fall Prevention | Injury Center | CDC. https://www.cdc.gov/falls/hip-fractures.html

CDC. (2021, December 1). Facts About Falls | Fall Prevention | Injury Center | CDC. https://www.cdc.gov/falls/facts.html

Quigley, P., & Tarbert, R. (2021). Tango Belt: A New Smart Hip Protector Solution. OJIN: The Online Journal of Issues in Nursing, 26(3). https://doi.org/10.3912/OJIN.Vol26No03Man05

WebMD Editorial Contributors. (n.d.). Why Do Older Adults Have More Falls? WebMD. Retrieved March 2, 2023, from https://www.webmd.com/healthy-aging/why-do-older-adults-have-more-falls