TrustFall

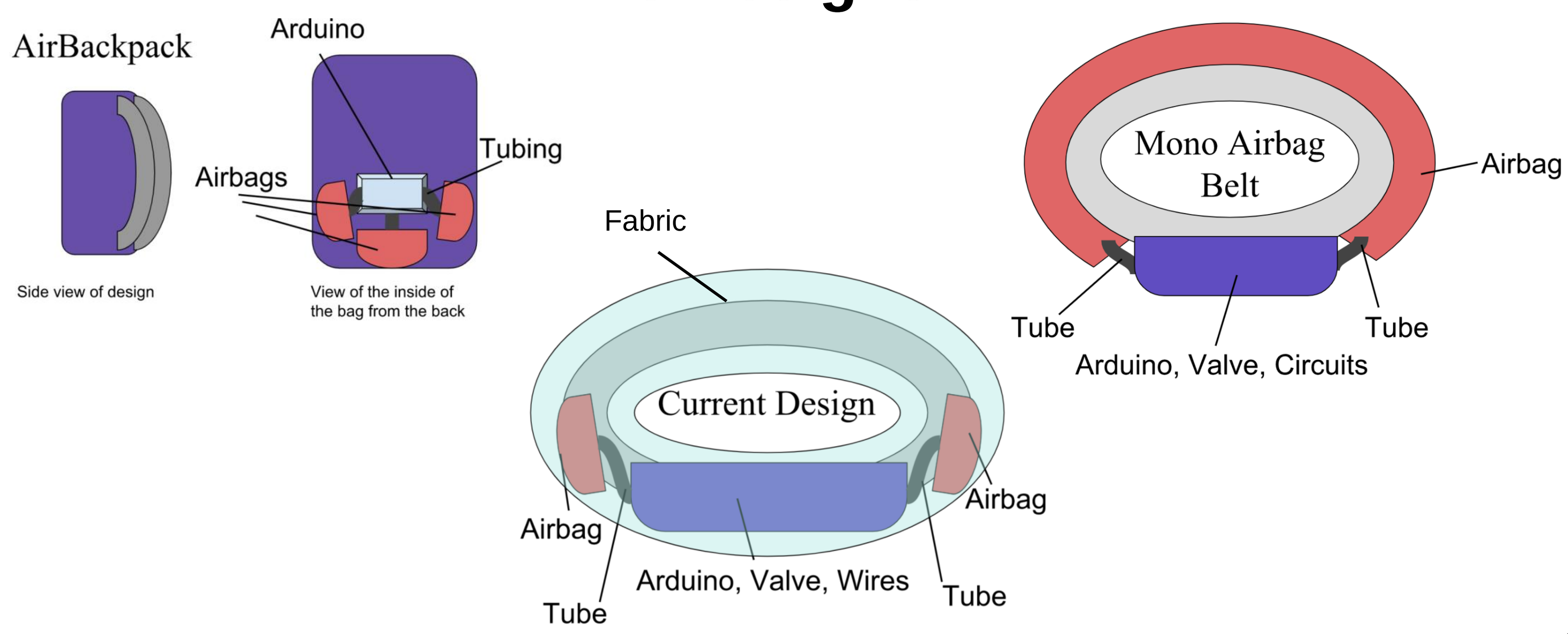
A device to protect the hips in the event of a fall

The ButterCats: CEO Venkatraman Varatharajan, CMO Shuling Lin, CTO Sumanth Sura, CIO Emily Wang
Advisor: Dr. Kevin Crowthers

Problem Statement

Adults over the age of 65 have a great risk of falling (WebMD Editorial Contributors, n.d.). Devices exist to prevent a fall, but there are very few devices designed to protect an individual during a fall.

3 Designs



Final Product

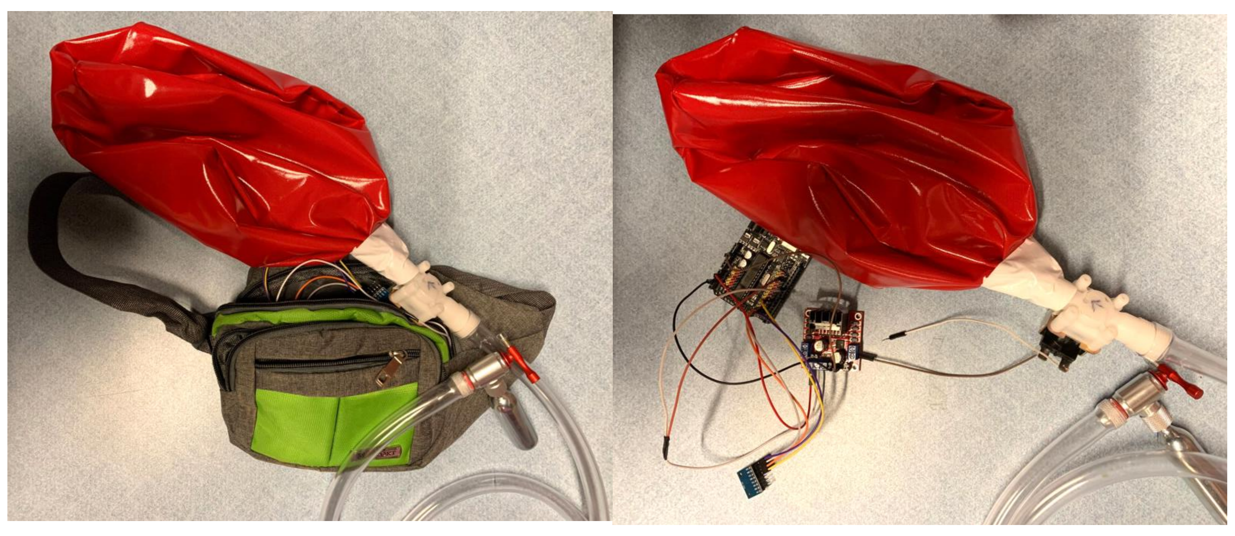


Figure 9. ***Final Prototype.*** A view of the final product with the circuitry inside the fanny pack and what the circuitry looks like.

Requirements

#	Requirement Type	Requirement Statement	Level	Current Design	Dual Airbag Belt	Mono Airbag Belt with Expansion Control	Airbag Belt
1	Functional	The device shall detect a fall with an accuracy of at least 90%.	1	TBD	TBD	TBD	TBD
2	Functional	The device shall reduce the impact of a fall by at least 60%.	1	TBD	TBD	TBD	TBD
3	Functional	The device shall detect a fall at least half a second before the fall.	1	Yes	Yes	Yes	Yes
4	Functional	The device shall inflate to its full size in under one second.	1	Yes	Yes	No	No
6	Functional	The device shall deploy without causing physical injury.	1	Yes	Yes	No	No
7	Physical	The method used to deploy the airbag shall not be dangerous to the user.	1	Yes	Yes	No	No
8	Physical	The device shall be concealable.	1	Yes	No	No	No
9	User	The user shall move unhindered when wearing the device.	1	Yes	Yes	Yes	No

Construction Methods

Machine Learning Models

- ❖ Collect data
  - ➢ Falling data (slipping and pivoting)
  - ➢ Safe data (stationary and walking)
- ❖ Train the model
- ❖ Export parameters to Arduino Uno

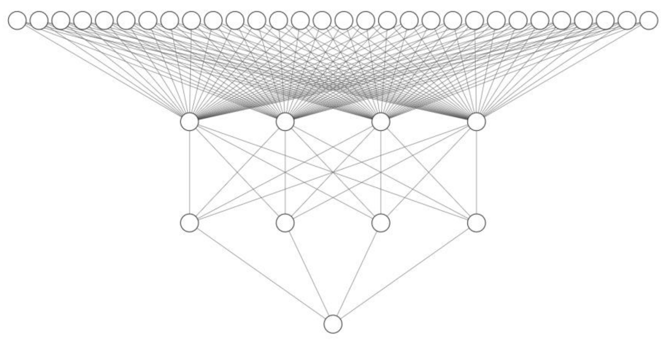


Figure 1. ***ML Model Architecture.*** A neural network with two hidden layers was used for the activation algorithm.

Hardware

- ❖ **Connect** Arduino to accelerometer and solenoid valve
- ❖ **Connect** bike pump adapter with an air canister attached to the valve
- ❖ **Connect** one side of the tubing to the exit port of solenoid valve and the other side to an airbag
- ❖ **Place** accelerometer, and CO_2 into the pouch

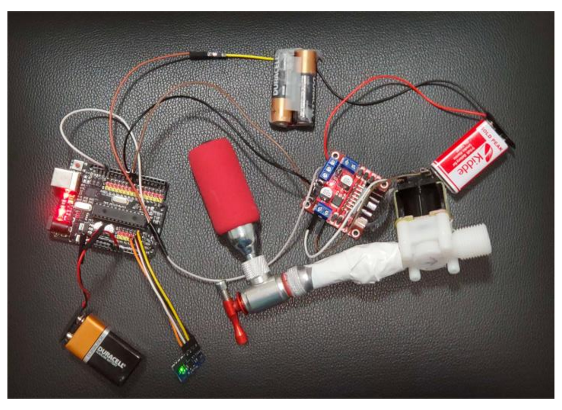


Figure 2. ***The design of TrustFall's hardware.*** An Arduino controls a valve, aided by a power controller and collecting data using an accelerometer.

Airbags

- ❖ **Cut** out airbag pieces according to template
- ❖ **Heat seal** edges together at about 400º C, inside out
- ❖ After ensuring there are no unintentional gaps in the sealing, **invert** the airbag
- ❖ **Attach** tubing to the airbag and seal the hole

Figure 3. ***Sealing airbag.*** A T-shirt press was used to heat seal the fabric seams.

Figure 4. ***Airbag after sealing seams.*** One of the airbags after sealing of seams and inversion of the fabric

Design Studies

Airbag Quality Study

- ❖ Used air pump to inflate airbag
- ❖ Tested forces applied in different methods (impact, concentrated force)
- ❖ Dropped objects to emulate the force of a human body in a safe manner
- ❖ Tested if it could support human weight
- ❖ Airbag displayed strong resistance to damage

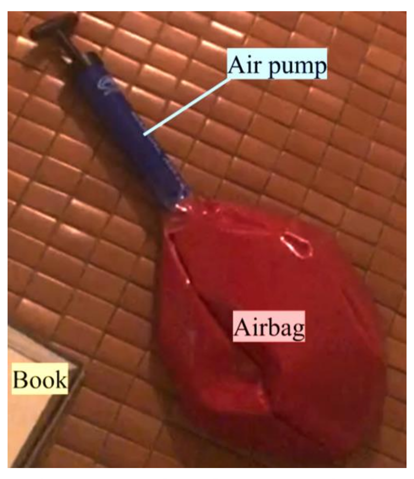


Figure 5. ***Airbag drop test.*** A book bounced off the airbag after impact during a force test.

Fall Detection Algorithm Study

- ❖ Tested for speed accuracy of ML model
- ❖ Tested different types of falls for both falls (pivoting and sliding) and non-falls (sitting and walking)
- ❖ Falls tested using PVC pipe
- ❖ Model detected fall with accuracy ~98.5% and 0.5s before impact after training

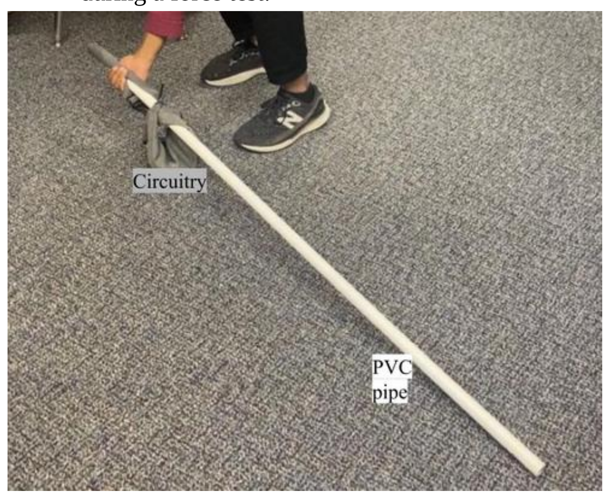


Figure 6. ***ML Data Collection.*** A PVC pipe is dropped on a high-friction surface to emulate a pivoting fall.

Valve Activation Study

Water

- ❖ Initial study to determine feasibility of valve
- ❖ Used gloves as inlet/exit ports on each end
- ❖ The valve successfully allowed transfer of water.

Air

- ❖ Tested if the valve is airtight
- ❖ Used balloons to monitor air transfer reliability
- ❖ When opened, empty balloon inflated slowly
- ❖ When closed, empty balloon inflated slowly

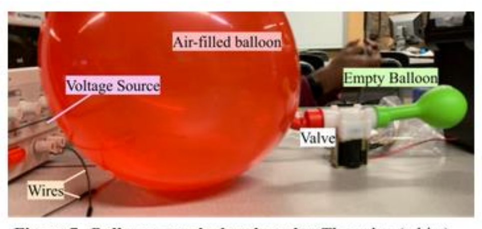


Figure 7. ***Balloons attached to the valve.*** The valve (white) with the two balloons attached. The air-filled balloon (red) is attached to the inlet port, and the empty balloon is attached to the exit port. The valve was connected to the voltage source using wires.

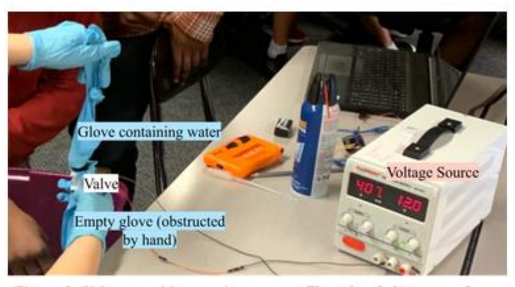


Figure 8. ***Valve test with water in progress.*** *The valve (left) is opened after receiving 12 volts from the battery source (right). The glove containing water is held above the valve, allowing water to flow down and through the valve.*

Conclusion and Future Work

Our device is limited by the materials we had available to us. CO_2 is not the first choice for car airbags because the inflation due to a chemical explosion is much faster and requires less mass. Additionally, we still faced challenges handling the CO_2 as our final plan involved having the CO_2 canister opened at all times but working with pressured air can be difficult. In the end, we ended up with a final product that was able to activate during a fall, and an airbag that was able to be inflated, but some inflation errors.

In the future we would first work on the activation of the inflation method for our device. After that aspect has been improved, we would look into improving our machine learning model and look into other methods for inflating our device.