AirSave - Fall Protect Exoskeleton

"Falls are Fatal, Let Air-Save You"

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Abstract

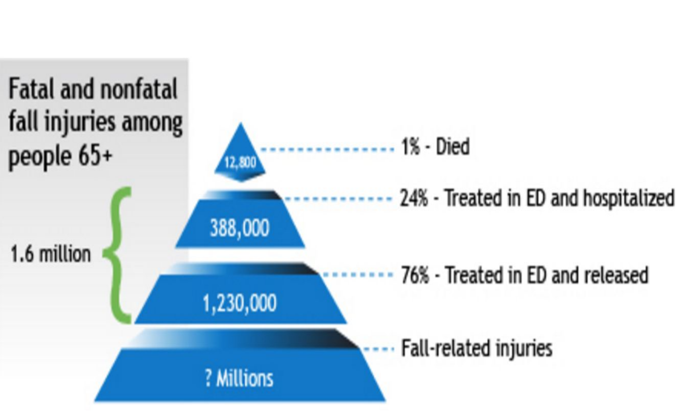
In this project, our team understands that the risk and impact of falling drastically increases as one ages past the age of 55. This is part of the symptoms of ageing, which includes decrease in bone density, decrease in motor function, slower reflexes, reduced motor control. All these can contribute to detrimental effects when seniors fall and lead to fatality. Because of this, our team is dedicated to create a tool that can protect senior citizen against fall related injuries - at their comfort.

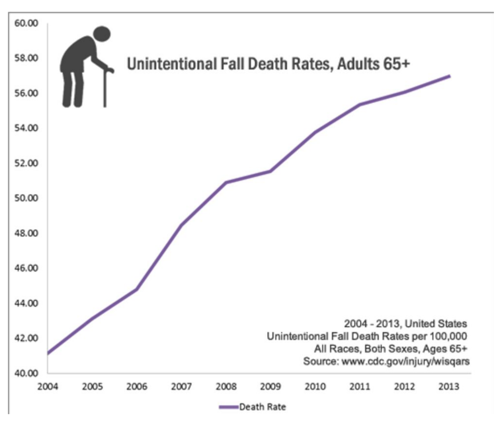
Identifying the Problem

Fall related injuries are exponentially more fatal as one ages, the danger of falling increases drastically after the ager of 55.

Shift in Population Age:

- 65.4 million Baby Boomers (Born in 1946 - 1964)





National Institute of Health:

- 1 / 3 individuals over the age of 65 falls at least once a year
- Over 1.6 million admitted to ER annually
- 87% of all fractures in the elderly are due to falls.
- Hip bones, spine, neck, and head injuries

Survey Statistic:

- 85% Seniors agrees falling is a serious hazard.
- 65% of the seniors would wear it, if it's comfortable and light

"I dislocated my left hip while taking a brisk walk and tripped. Also, I just fell off a step ladder 2 days ago fracturing my right shoulder"

"Two family elders in their 90s...falls led to death"

Management of Fall-Related Injuries in the Elderly: A Retrospective Chart Review of Patients Presenting to the Emergency Department of a Community-Based Teaching Hospital

Table 3

Fall Description at Time of Presentation to ED for Patients with a Fall-related Injury

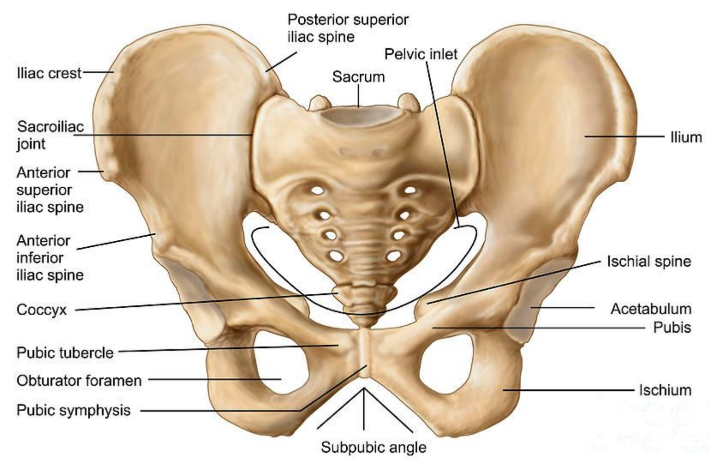
	Discharged from ED (n = 245) n (%)	*Admitted to Hospital (n = 55) n (%)*	*Total Sample (n = 300) n (%)*
Fall description:			
Fell on stairs	50 (20.4)	7 (12.7)	57 (19.0)
Fell on ice	27 (11.0)	2 (3.6)	29 (9.7)
Fell on curb/sidewalk	28 (11.4)	4 (7.3)	32 (10.7)
Fell from bed/chair/couch/ wheelchair	22 (9.0)	10 (18.1)	32 (10.7)
Tripped on other object	34 (13.9)	9 (16.4)	43 (14.3)
Unexplained fall	49 (20.0)	15 (27.3)	64 (21.3)
Other	34 (13.9)	8 (14.6)	42 (16.7)
Fall location:			
Inside home	78 (31.8)	28 (50.9)	106 (35.4)
Outside home	92 (37.6)	15 (27.3)	107 (35.7)
Not documented	67 (27.3)	11 (20.0)	78 (26.0)
Diagnosis:			
Laceration	42 (17.1)	0 (0.0)	42 (14.0)
Fracture	71 (29.0)	42 (76.3)	113 (37.7)
Head injury	25 (10.2)	4 (7.3)	29 (9.7)
Soft-tissue injury	49 (20.0)	3 (5.5)	52 (17.3)
No diagnosed injury	50 (20.4)	2 (3.6)	52 (17.3)
Other	6 (2.4)	4 (7.3)	10 (3.3)
Loss of consciousness:			
Yes	6 (2.4)	6 (10.9)	12 (4.0)
No	138 (56.3)	32 (58.2)	170 (56.7)
Unknown	8 (3.3)	2 (3.6)	10 (3.3)
Not documented	90 (36.7)	15 (27.3)	105 (35.0)
Alcohol use at time of fall:			
Yes	6 (2.4)	2 (3.6)	8 (2.7)
No	9 (3.7)	9 (16.4)	18 (6.0)
Not documented	229 (99.6)	44 (80.0)	273 (91.0)

*If percentages do not add up to 100%, this is due to missing data

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2788319/table/T3/ 1/2

Impact Data Calculations

Dataset: The hip is the most fragile and most injured area due to falls, so we focused our calculations on hip impact.



Pelvis Anatomy

CO2 Cartridge
Pressure = 900PSI
Volume = 20 cm³

Assuming the height of a hip is .9 meter, the impact velocity of the hip hitting the floor at free fall can be calculated using this equation: $v_f^2 - v_i^2 = 2ad$.

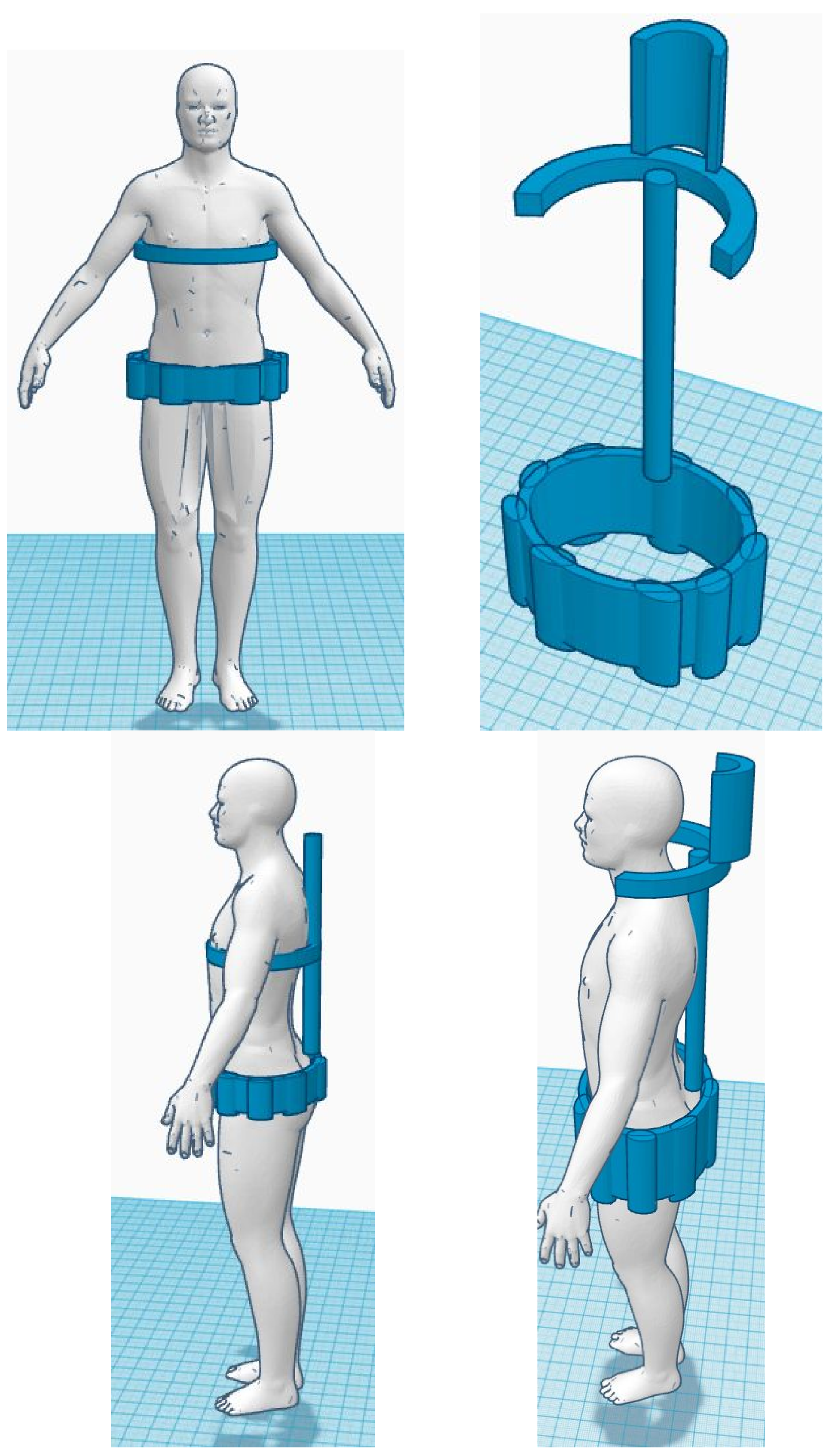
vf = rad(29*8*9) =4.42 m/s This represents the velocity upon impact. The force associated with this impact needs to be calculated from the velocity and the mass of an 82Kg individual.

Energy and Force of Impact:

Energy = .5*m*v² = .5*82Kg*4.42 ^{2} = 800.99 Joules
E = F*d
d = 2 inches for the air bladder or around .0508m
Average Force = 15767 Newtons

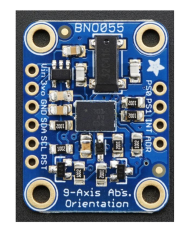
The problem we want to solve is how much pressure the air bladder would need to have to absorb this impact effectively. Pressure = Force/Area, the Area is the approximate area of the air bladder, which is 3 x 7 inches (0762 x .1788 meters: .0136m^2)

Force/Area = 15767 Newtons/.0136m^2 = Pressure = 1159338 Newton/ Square Meter = 168.14 PSI should be supplied to the air bladders. Given the CO2 cartridge has approximately 900 PSI, 6 airbags around the body should be sufficient. Since we are using 2 CO2 cartridges, we can use 12 airbags, with variable size.

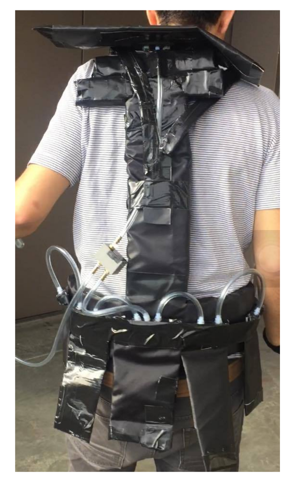


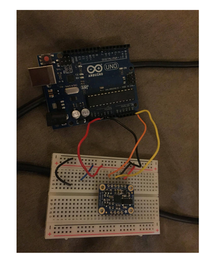
Method of Detecting Fall

In the fall detection process, we employ a BNO055 3-axis accelerometer and a gyroscope to detect the motion, and utilized a combination of thresholding as well as SVM classification algorithm analyze the algorithm.



BNO055 Sensor

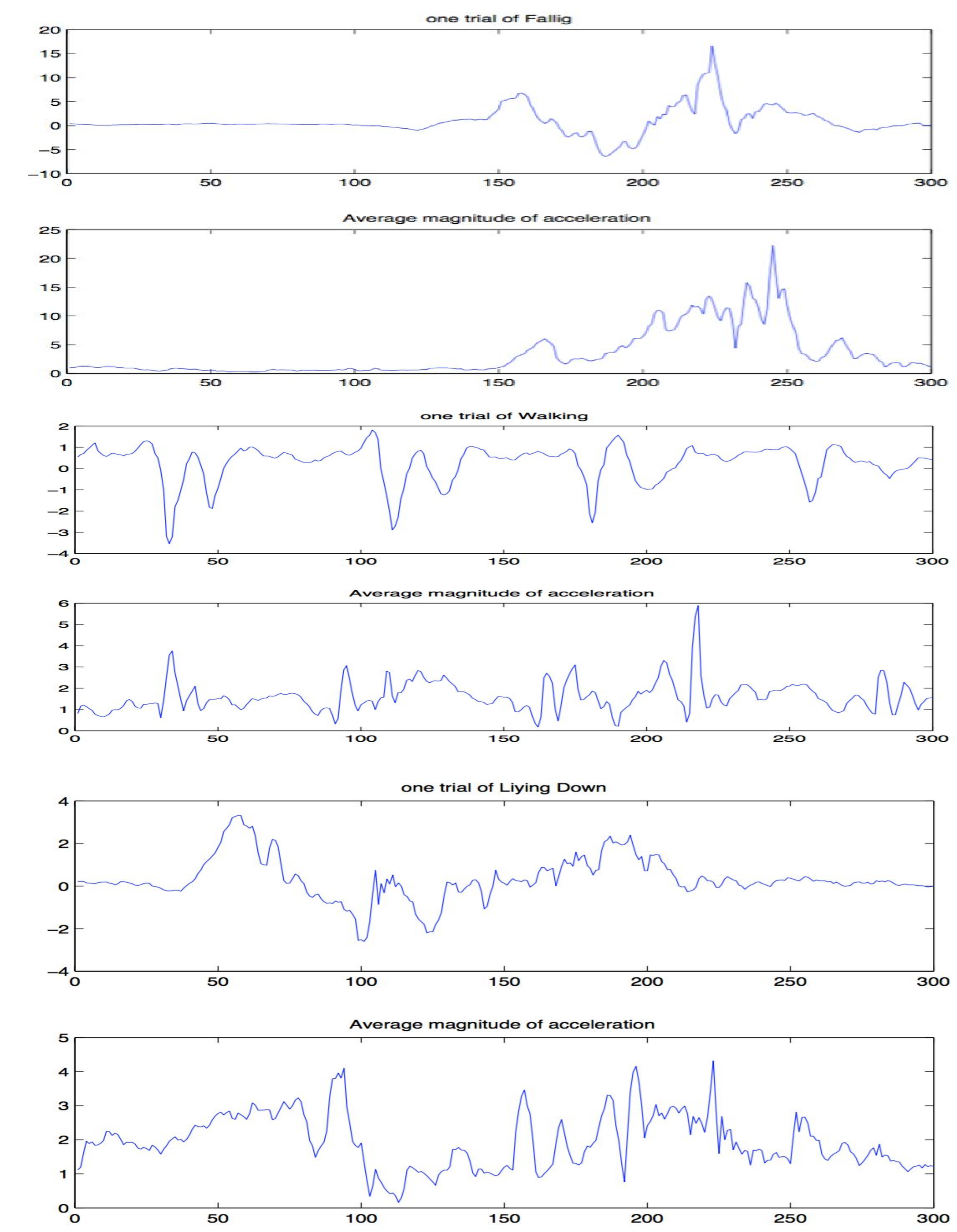




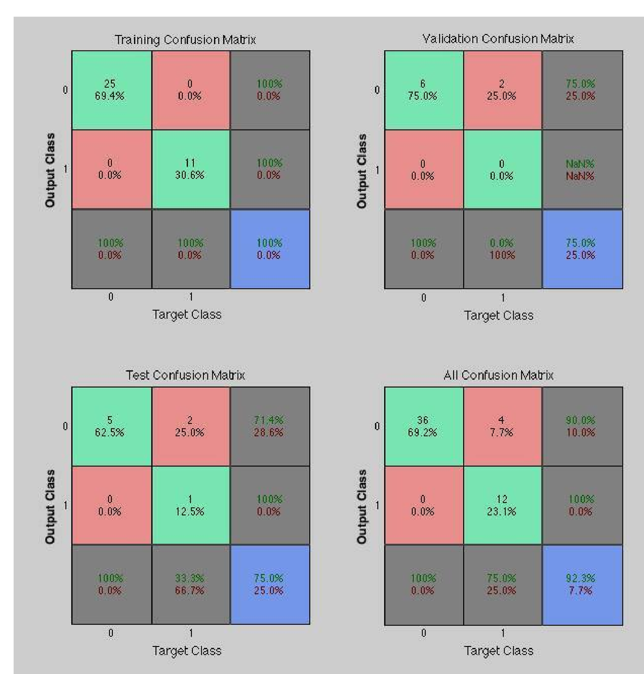
Circuit Set-Up

Data Collection (Spine Placement):

- We attached the sensor on the upper spine of the user, and collected increments of 5 second data samples for 8 activities. These activities include positives (Falling) and negatives (Non-Falling). Listed below are the sensing magnitude of the accelerometers:



SVM TEST RESULTS



Validation Matrix-
Portions train data which used to measure the performance of training

Test Matrix:
Tests the classifier on new data to see how well it detects the fall on random sample activities.

Conclusion

Our research shows that falling is a serious issue that requires attention. Through our effort, our thresholding algorithm can always detect a fall from normal activity was as walking, standing, sleeping, etc. however, differentiating from falling activity will require much more data sample to train the SVM classifier to achieve maximum results. In addition, the inflation process for the airbag is around 0.5 seconds.