Wheelchair safety has remained a strong innovation topic in the healthcare industry as the number of wheelchair users grows at a rapid rate. In 2016, there were over 3.3 million wheelchair users in the United States alone with 1.825 million of those users aged 65 or above. With this strong number of elderly wheelchair users, the probability of wheelchair prone injuries increases. Out of all wheelchair injuries, wheelchair tips and falls lead as one of the highest cases as a study in 2003 found that tips and falls accounted for approximately 65-80% of all wheelchair related injuries. Additionally, as increased innovation is made towards furthering wheelchair user independence in society, the likelihood of wheelchair users living alone is expected to rise. There is a robust financial case to make our wheelchair safety system a viable business. There are no intelligent wheelchair systems available, despite the large market. Senior citizens with limited mobility are also often unable to live autonomously. Living under constant care in a nursing home or a relative while performing simple chores becomes difficult. Currently, no solution alerts caregivers and close contacts when an individual who uses a wheelchair tips and falls. The market has a few similar ideas, but there have been none that have exited the design phase.

This project will be focused on developing a smart wheelchair system capable of reading both wheelchair motion and user heart rate in real-time to detect when wheelchair falls have occurred. Using the live data, an alert is immediately sent to caretakers or loved ones through SMS or an app alert when a wheelchair fall has been detected, allowing for prompt and possibly life-saving care for the wheelchair user. Based on this main hypothesis, the following objectives for this project are formulated: a.) to detect when a wheelchair/user falls in either left, right, forward, or backward direction; b.) monitor heart rate of user; c.) provide immediate communication of fall to caretaker/loved one. Potentially an app could be created to keep all the heart rate data recorded for future use and a notification would be sent to the caretakers or loved ones in case of a fall. The goal of our heart rate monitoring objective is to provide caretakers and doctors with more patient data to allow for a thorough analysis post-fall of a patient’s medical health. This feature is also especially beneficial for those with heart disease and special reduced mobility.

**Cons**

The biggest issue with this project would be novelty as our professor mentioned. There were many projects made in the previous semesters using a wheelchair which could potentially make this idea rather “simple”. We might need to add more features to make it more complex (eg. Active control to stay upright, airbags etc). Signal processing for the ECG data might take longer to perfect by trial and error, that might be why it might be better to analyze ECG data on MATLAB before writing code in another language.

For this design, we can use the 3-Axis ADXL335 Accelerometer which costs between $14.95-16.50 and connect it to an Arduino. For the ECG component we can either use the SparkFun Single Lead Heart Rate Monitor AD8232 ($21.50) or build the ECG on a breadboard using low pass and high pass filters and an amplifier and connect it to an Arduino. Building an ECG on a breadboard will cost around $100.

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| --- | --- | --- | --- |
| Description | Quantity | Cost | Total |
| Arduino Mega 2560 Rev3 | 1 | $40.30 | $40.30 |
| Texas Instruments General Purpose Op-Amp | 3 | $1.03 | $3.08 |
| 9V Battery | 3 | $4.75 | $14.25 |
| 9V Battery Clip | 3 | $0.59 | $1.76 |
| BioProtech Universal ECG EKG Electrodes | Bag of 100 | $19.95 | $19.95 |
| Capacitor 18nF | 1 | $0.16 | $0.16 |
| Capacitor 33nF | 1 | $0.19 | $0.19 |
| Capacitor 1 uF | 1 | $0.49 | $0.49 |
| Capacitor 10 uF | 1 | $1.99 | $1.99 |
| Capacitor 20 uF | 1 | $0.39 | $0.39 |
| Resistor 1k ohm | 1 | $0.51 | $0.51 |
| Resistor 10k ohm | 2 | $1.09 | $1.18 |
| Resistor 100k ohm | 4 | $0.49 | $1.96 |
| Resistor 200k ohm | 3 | $0.49 | $1.47 |
| Resistor 1.1M ohm | 1 | $0.49 | $0.49 |
| Resistor 3M ohm | 1 | $1 | $1 |
| Breadboard | 1 | $5.99 | $5.99 |
| Total | $95.16 | | |

The design will first start the calibration by connecting to the Arduino board and start data acquisition for a few seconds to calculate the threshold and alert levels. After the calibration is completed live data tracking with alerts will be enabled and the program will check for breaches of alert levels. When the collected data Is above or below a certain threshold, alerts will be triggered, and a notification is sent.

There are numerous paths to market for this design; these include selling the intelligent wheelchair safety system directly to the patients and their families, selling to hospitals, and selling to assisted living homes. The unique selling proposition for this product is its intelligence - by automatically detecting and reporting a tip or fall to the user’s close contact and healthcare provider, pertinent data is relayed almost immediately, and the user can receive assistance faster. These scenarios often occur when the user is too injured or disoriented to contact their loved ones for help. The healthcare provider can also stream ECG data from the time of the accident to view heart rate information, adding additional information that may be pertinent when assisting an individual. After reading numerous case studies and reports, an appropriate business model is identified, which considers a gap in the market, addressed via this innovative solution.

**Things to add to make the design more complex**

Active control for a wheelchair to stay upright (would not need fall detection)

A device to help stand up from a wheelchair

EMG sensors to measure muscle response (could be useful for users who have limited muscle activity to see the response to the nerve’s stimulation of the muscle)

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| --- | --- | --- | --- |
| Seeeduino V4.2 | 1 | $7.60 | $7.60 |
| Grove | 1 | $32.90 | $32.90 |
| EMG Sensor Measuring Module for Arduino | 1 | $26.76 | $26.76 |

**Related research on smart wheelchairs**

H. Vora, A. Gupta, C. Pamnani, and T. Jaiswal, “Multimodal Smart wheelchair integrated with safety alert system,” International Journal of Engineering and Advanced Technology, vol. 9, no. 4, pp. 1324–1330, 2020.

M. A. Rahman, S. M. Ahsanuzzaman, A. Hasan, I. Rahman, T. Ahmed and M. M. Kadir, "Building A Wheelchair Controlling and Fall Detection System Using Mobile Application," 2020 2nd International Conference on Advanced Information and Communication Technology (ICAICT), 2020, pp. 213-218, doi: 10.1109/ICAICT51780.2020.9333478