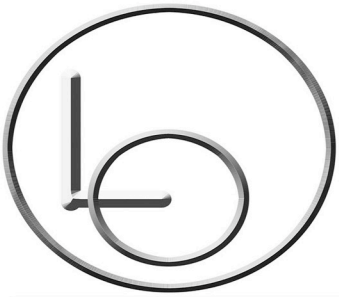

Post Mortem for Fall Assist, a device to detect elderly people who have fallen

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1. Introduction

Falls are a major concern for elderly people living on their own. Statistics show that approximately one in every three adults 65 years old or older fall each year and 30% of the falls result in serious injury [1]. The United Nations predicts that by 2035, 25% of the world population will be aged 65 years or older as the baby boomers age [2]. Quick detection of a fall can lower the rate of mortality and increase the chances of survival.

Fall Assist allows seniors who are prone to falling gain back their independence of living alone. With *Fall Assist*, seniors can live their lives without the worry of falling and having to wait hours or days until someone finds them to bring help. *Fall Assist* is a device that is worn around the waist that will automatically detect when a fall has occurred and contacts help. The fall is detected by an accelerometer that is located in the belt buckle of the belt. Once a fall is detected, the microprocessor sends a text message to the user's emergency contact that their help is needed immediately using Wi-Fi. The user has the ability to easily setup and change their emergency contact's phone number using a simple easy to use web application. *Fall Assist* works wirelessly and without the need of input from the user. This simple and automatic device allows seniors' to live worry free in their own home and ensures that help is brought to them when they are in need and unable to call for it themselves.

2. Description of the System

The user's activities such as walking, sitting, climbing stairs, etc. generate readings in the accelerometer. These readings are then passed to the microcontroller where they are then analyzed to be a fall or not. If the microcontroller determines that a fall has occurred, it connects to the Wi-Fi connection in the user's house and sends a text message to the emergency contact.

Fall Assist at its highest level can be seen below in the figure 2.1.

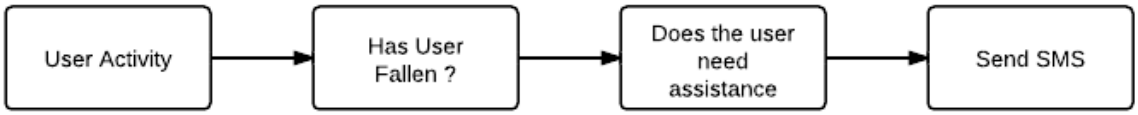

Figure 2.1: Flowchart for *Fall Assist*

The first unit is the fall detection system. The device is worn as a belt and consists of an accelerometer and a microcontroller. This will detect whether the person has fallen or not.

The second unit is the Wi-Fi transceiver. This connects the belt to the Wi-Fi connection in the user's home. The user may need some technical assistance in setting up the Wi-Fi connection on the belt.

The third unit is the web application which sends a text message to the emergency contact. This will have an intuitive interface and is where the user enters the information of their emergency contact. This sends a text message to the emergency contact once the system determines that the person has fallen and needs assistance.

Together, all three units make up *Fall Assist* and are able to alert the emergency contact via text message that their assistance is needed after a fall has occurred.

3. Problems and Challenges Encountered

One of the main problems encountered was that we ordered the incorrect parts at the beginning of our project. We were unsure which microcontroller to use and ordered a few incompatible ones while determining which would be easiest to use and program for our design. We also ordered a few accelerometers during this time so that we could get started as soon as the parts arrived. Finally, we chose to use the LPC2148 ARM development board because the board also contained a 3-axis ADXL345 accelerometer.

While researching how to program the ARM microcontroller, we learned that our design would have been a lot easier to implement on an Arduino microcontroller. This is because they are open source so a lot more examples are available on the Internet. Arduino boards are also backed by a growing community and a lot of source code is readily available to use on the Internet. Furthermore, using an Arduino board would not only have been easier to use, the price would have been less than the ARM board we decided on.

Another problem we encountered was that our microcontroller board did not have a speaker attached to it. The microcontroller has the capability to play an mp3 file; however, the sound is outputted through an audio jack and adding a speaker on the device would make it bulkier.

After working with the ARM development board, we learned that there was very limited documentation on the microcontroller and the board. This again would have been solved by using an Arduino board because the Internet contains large amounts of documentation and information on them.

Another problem we encountered was that we underestimated the time for shipping. We ordered the EasyWif board later in the semester and even though priority shipping said it should have been here by a specific date, we were still waiting days after that for it to arrive.

A challenge we countered, while creating the algorithm to detect a fall, was the accelerometer scaling. Figuring out the scaling took a lot longer than expected and delayed the progress with the task of detecting a fall. Eventually this challenge was overcome, but it took approximately two extra weeks than expected to deal with.

4. Future Plans

Fall Assist's current proof-of-concept model still has work for future development. Our current proof-of-concept model shows the basic concept of *Fall Assist* but it is not in its final state appearance wise or usability wise. Also, the accuracy of detecting a fall could be even further improved.

Fall Detection

Currently, *Fall Assist's* accuracy for fall detection is ~90%; however, this precision could be greatly improved with the addition of a gyroscope. It was not possible to add a gyroscope during the development of the proof-of-concept model due to time constraints.

Usability

A user interface would need to be created for the user to enter their emergency contact's information. This interface would need to be easy to use so that the user could easily add and change the phone number and message that is sent when a fall is detected.

Physical Appearance

In order for *Fall Assist* to be produced for the public, the entire device must fit within a small, lightweight belt buckle. A single printed circuit board would need to be designed to hold all the components and consume minimal space. Also, the belt buckle to hold the device would have to be designed to be fashionable, comfortable, and waterproof.

Battery

Further research would have to be done on types of batteries to find the optimal battery for this device. Battery life, weight, and the ability to recharge easily would be major factors in determining the correct battery for the final product. This ideal battery was not determined for the proof-of-concept model due to time constraints.

5. Actual and Estimated Budget

Table 5.1 shows the actual expenditures of the development of *Fall Assist*.

Table 5.1: Actual Costs

Equipment List	Actual Cost
2 x ADuC7026 Microcontrollers	**$50**
2 x ADXL345 Accelerometers	**$15**
2 x HC12 Microcontrollers	**$30**
Nerdkit	**$150**
LPC2148 Development Board	**$200**
EasyWifi Board	**$120**
Priority Shipping	**~$150**
2 AAA Batteries	**$10**
Wire Jumpers	**$10**
Total Cost	**~$735**

The original estimated cost was set at $688; however, since that estimate was made, our design has changed. Some components were eliminated, and some were switched to an alternative design. Even with these changes, the total expenditure of the project was similar to the original estimated cost.

Furthermore, some incorrect parts were ordered early in the development stage. If these extra parts are eliminated, the total actual cost comes to approximately $500. Which would be below our estimated budget.

At the beginning of the semester we received $700 from the ESSEF (Engineering Science Student Endowment Fund), which nearly covers the entire cost of *Fall Assist*.

6. Actual and Estimated Timelines

Below table 2 shows our estimated completion dates and our actual completion dates.

Table 6.1: Development Timeline

Milestone	Estimated Date	Actual Date
Finish Research	**End of February**	**End of April**
Assembly of Modules	**Mid March**	**First week of April**
Integration/Testing	**End of March**	**End of April**
Debugging	**End of March**	**End of April**

All of our actual completion dates were approximately a month after our estimated completion dates. When the design of *Fall Assist* began, it was expected that most tasks would take longer than expected; however, it was not expected that each would take a whole month longer.

One thing that could have helped with our time management would have been to create a more detailed schedule from the beginning. Our original planned timeline was based on vague milestones like finish research and debugging. This was due to the fact that when we proposed this project, we were still unsure of our design and of what most of our milestones would be. Our design constantly changed throughout the semester after continuing research and experimenting with different components. Most of our deadlines were set on the go and were to finish a task by the end of that week.

Even with our lack of a clear, structured schedule, we were able to complete a working proof-of-concept model by the deadline.

7. Interpersonal and Technical Experiences

Ashish Argawal

It has been a privilege over the last few months to have worked with a group of highly motivated people.

It was great fun to see the different parts of the project slowly working one by one and then the whole system work when we put the different parts together. A week before the deadline, the whole system just worked. It was a thrill to see to see a person falling and a text message appear on the phone a few seconds after.

The project gave me exposure to embedded systems programming and I learned about the different types of microcontrollers, their pros and cons and how to hook them up together. I was able to connect them together.

I had set a few goals for myself for this project – to learn embedded systems programming, develop a web application and a smartphone application. Although the smartphone app was nixed since it was not a very good design, I was able to accomplish the first two goals.

Looking back, we made a number of mistakes and we also did a number of things right. We would have liked to use gyroscopes and a 3G chip as well but we needed a few more weeks for that. In the end, given the amount of time we had, I am happy with everything we accomplished.

Richard Cho

It has been a very eventful 4 months. I knew it would require a lot of energy and attention but the learning curve was overwhelming at times. However, it was a very satisfactory to experience a working product in the end.

Technically, we faced a lot of difficulties from the start. We had no idea which microprocessor or any other parts was to be used, and ended up buying wrong parts which cost us time and money. Even after we have bought an ARM board, with zero experience with them it was a difficult task to overcome. In addition the wifi chip that is designed to work optimally with PIC boards proved to be big frustration for us. As a result, in such short period of time we had to resort to building a functioning product rather than a reliable product we have designed at the beginning.

Through all the hardships, we were able to pull the final product together thanks to my determined teammates that never gave up. We motivated each other to complete the project and always put out best possible solution available. Our

team dynamics were good, as we have not stirred up much problem during the process.

On a final note, I do have some regrets on how the project as a whole went. With some better planning and some structure, the experience would have been much less stressful. For example, had we looked closely into which parts were being ordered and were compatible with each other then we would have had much more time in our hands. Also, the lack of structure in our team proved to be a bit of a problem when we were arranging time or making a decision. It's also a shame that we only get 4 months to work on such a vigorous project. With more time I believe a better product could have been made. All in all I have learned a lot through various mistakes, but also achieved a lot through the project.

Mahsa Dabirvaziri

ENSC 305W/440W course was challenging and fun at the same time. The difficulty of this course was learning new skills in the limited time; however, the flexibility of choosing the type of tasks made the course exciting. Throughout this course, I enhanced my technical and non-technical skills, which are great achievements for my professional life. I would like to thank Dr. Andrew Rawicz and Mr. Steve Whitmore for all the time and effort they put on the courses directing me to accomplish this goal.

I learned a general understanding of each part of the project. Whenever I had time I asked other members of the project if they needed any help or I joined them to learn more about other parts. I mainly worked on the EasyWifi Board and Battery Boost Shield. I researched on how to use the EasyWifi Board and I found some documentations and examples to help our project. Then Lukas-Karim guided me how to connect it to the other board. I researched the Battery Boost Shield and its connection. I attained these new technical skills by working hard and in the end it was rewarding.

I did not know anyone in my group and I met them for the first time in the first class of this course, so I managed to get to know them from the first day to have more clear communications. Limited time for the project pushed me to improve my time management skills. Researching, planning, and working individually are some other skills that I improved while accomplishing this project.

As a group, we started with a plan and we finished with a working product. I am proud of my group members as well as myself. I would like to thank them for all their hard work and it was nice to meet them all.

Paven Loodu

My role in the project consisted of working on the algorithm for detecting a fall. Duties included programming a LPC2148 microcontroller and measuring acceleration values in the x, y , and z-axis. Using threshold values obtained from everyday activities such as walking, lying down, and climbing stairs a fall could be detected when comparing these values to the acceleration experienced throughout a fall.

From the beginning of the course one of my main goals involved learning and becoming more familiar with the C programming language and this project allowed me to do so. The core of the project involved producing an algorithm for detecting a fall and it was all written in the C programming language. Main concepts that I became more familiar with were the communication protocols such as Serial Peripheral Interface protocol and Inter-Integrated Circuit that are responsible for communicating with different modules.

I also gained valuable experience working with a group of 4 during a condensed 13-week project course. I learned how to delegate work amongst the team members accordingly and how to deal with deadlines and pressure.

I had a pleasant experience working with my team members and believed everyone rose to occasion and put in a good effort to get the project complete and more importantly to walk away from the project learning more about myself and what I have learned in the last 13 weeks.

Alysha Sue

When we started this project I was afraid that I would lack technical knowledge compared to everyone else. I was afraid that everyone would be pulling my weight for me because of my inexperience. However, I soon learned that very little of what they teach you in school would ever help with designing and creating whatever idea you chose to pursue. I also quickly learned that my group members didn't know things like which microcontroller would be best to use either and that the Internet would become our best friend for surviving this project.

During the process of learning that I was not as far behind my group members as I thought, I undertook the roll of managing the writing portion of the class to ensure I pulled some weight. I organized what sections needed to be written for each document, assigned everyone a part, and set a deadline that they had to be sent to me by. I compiled, edited, ensured that each paper was written to the best of our knowledge and submitted them on time. By taking on this role of the document manager, I gained invaluable experience with team managing.

As for technical experience, I gained knowledge with hardware connections. I had never dealt with hooking up components before so this was all new knowledge to me. While connecting the microcontroller board to the Wi-Fi board, I learned how the components of SPI (serial peripheral interface) connect together as well as general input/output pins. I also learned how microcontrollers save space by using one pin for multiple inputs/outputs by setting registers to choose between the options. I've never had any experience with hardware before but this small tid-bit has made me want to experience more in my future.

Even though I gained lots of experience in different areas throughout this process, the biggest lesson I learned was, as Murphy's law states, that "anything that can go wrong will go wrong." I had not anticipated the shear number of problems that can and did arise during the whole development process. I'm glad that my group members were always there with me to fight through whatever problems were thrown our way. Creating this proof-of-concept model would not have been possible without them.

8. Conclusion

In approximately 4 months, Century Solutions was able to design and create a working proof-of-concept model for *Fall Assist*. The proof-of-concept model could successfully detect a fall and contact help. Furthermore, this proof-of-concept model is by no means the final production model. The work still needed to put *Fall Assist* in its final form mostly involves increasing accuracy, usability, and physical appearance. The design of *Fall Assist* has potential to be marketed due to its low cost and high demand by the aging baby boomer population. Century Solutions is still fully devoted to improving seniors' living conditions and increasing their happiness by allowing them to live independently in their own home for longer with the help of *Fall Assist*.

9. Sources and References

[1] "Falls Among Older Adults: An Overview" Internet: http://www.cdc.gov/homeandrecreationalsafety/falls/adultfalls.html, Sept. 16, 2011 [Feb 2, 2012]

[2] Israel Gannot, Ramat-HaSharon, Dimitry Litvak, Tel-Aviv, Yaniv Zigel. "System for Automatic Fall detection For elderly People". U.S. Patent 0224925, September 10, 2009