Project A.W.E.S.O.M.E - Shoes

(**A**ll-including, **W**ireless, **E**co-friendly, **S**ustainable, **O**UTside-oriented, **M**obile, **E**nergy-harnessing - Shoes)

1. Introduction

The OUT - project: An open framework consisting of our own imagination, the concept of keeping it green, and a challenge to get people (and technology) *out* from their comfortable indoor habitats. When we started brainstorming, we only wanted to put a couple of constraints on our imagination and project. Those constraints were: it has to be green, and it has to promote activity through technology and live up to the mobile aspect of the course, along with the user. How can we make a project based on mobility, eco-friendliness and technology?

After a solid brainstorming, we eventually thought about how we can harness the energy that we are already "producing" every day, store it for re-usage, sell it or directly use it in conjunction with another item. A member of the group had a friend who told him about how they plan to harness energy in high-traffic highways by putting something under the road, to harness friction from cars. From this we thought if there is a technology that can be used in that situation, why not take this type of technology for granted in say, 5-20 years, and then try to expand upon our project with this kind of mindset ("what if...").

We wanted to find a way to harness energy from movement. Through your feet, or whatever mode of transportation you use (it must be usable for all people, wheelchair etc too). For fitness-enthusiasts and people who regularly enjoy the outdoors, we didn't see any problem with use. For people who would rather enjoy a cozy day at home, on the other hand, we thought an incentive was needed. Maybe a type of tax-deduction or insurance-bonuses would be a nice reward for using this technology.

2. Literature review

We started our project by searching and reading the articles in the same field. By doing that we can see how other's attempts to solve the equivalent problem and some work done by others that somehow tie in with our own work. We seek to gain knowledge from even minded individuals, doing research in the

same domain as us. The harnessing of energy and storing of such has been a large factor of our study material, as our work will mainly focus on this technology.

Other articles have also been acquired for the sake of a broader perspective on our area of interest.

The articles [1], [2] are basically about principles and state in motion-driven miniature energy harvesters, current development, trends and suitable applications. Both articles mentioned that in the field of motion-energy harnessing, the most promising way to extract energy more innocuously from people is by tapping their movement. In the articles [3] and [4], we find out how to harness energy by using shoes and how to use the energy, once collected.

In article [3], the author points at how the idea of harnessing energy by using shoes came out by mentioning that "*the average person spends a significant part of the day on foot, dissipating abundant energy into the insole of a shoe. Harnessed unobtrusively, this wasted energy could be used in a variety of low-power applications, such as health monitors, RFID tags and emergency beacons or locators. And a battery could be trickle-charged at the shoe and manually moved into the devices.*"[3]

Both articles [3] [4] presented three different devices, which can be built with a shoe to generate energy while walking. The first device tap's energy by harnessing the bending of the sole (They call this a PVDF stave). The shape of stave was chosen to conform to the footprint and bending distribution of standard shoe sole. The second was called "PZT unimorph", and was attached to a curved steel plate, which flexes under the pressure of a heel strike. Both of these devices are piezoelectric systems, which is basically a type of material that creates a charge whenever mechanical pressure is applied. The third one is a magnetic rotary generator. By mounting it on the shoe, it is mechanically coupled to the sole's dynamics or foot strikes. After the performance of these three devices was tested, the conclusion was that "*Although the magnetic rotary generator that we have tested produces 2 orders of magnitude more power than either of the piezoelectric systems, it is much harder to integrate smoothly into the design of conventional footwear without interfering significantly with the form factor of the shoe and / or gait. Both the PVDF stave and PZT unimorph were easily integrated into a standard jogging sneaker and sufficient energy could be accumulated across several steps to power useful functions.*"[4]

One use case was that energy was used to; "*transmit the users' identities to the local surroundings. The IDs can enable a central server to make dynamic, near-real-time decisions to personalize the environment or route appropriate information to mobile users.*"[3] Casting light on the connections between the technology and the surroundings, we started reading [8], which is an article about Ubiquitous and Wearable computing. The article is about the connections made between certain artifacts, and the issues around this or more generally explained - Communicating with your surroundings / environment. As we wish to gather data and energy with these shoes as well as have them communicate with base stations and maybe your own PC, it seemed like a logical step, to look further into this. Ubiquitous

computing could be described as "*For example, air conditioners and lights might automatically turn off when no one is in the room, or blinds may open and close depending on natural light levels in the room*"[8] and could for us be used for many things, such as transfer data between terminals or over wifi to be posted on facebook and such for comparative reasons. This is more about the shoe communicating with the environment. Problems with this technology is according to the article mostly based on privacy issues, but also the constant maintenance on personalized information for every user. The Wearable computing (which would be the shoes) is another approach that puts all the technology on the user, and in its purest form, as the article states; "*would do all detection and sensing on her body, requiring no environmental infrastructure at all.*"[8]. This does come off as a more secure solution, but according to the author, strives with issues such as; "*if information about a single location gets updated, then every wearable needs to be given the new information. Furthermore, is it often difficult for a wearable system to sense information beyond the user's local area.[...] Wearables are also not well suited to managing resources among several people*."[8].

In addition to the research done for the current state of this technology, we have also looked into research done with rewards and incentives done for the sake of promoting personal health responsibilities. In the article; "*Bonuses as Incentives and Rewards for Health Responsibility: A Good Thing?*" by Harald Schmidt [5], we've tried to gain some insight into our idea of something similar. For us and our project, a main goal is being able to use the data we've gathered in the shoes to something helpful. The energy is one thing, but the data is another. We wish to use this data in a way that people can prove their efforts done through walking or running, and use this data for a range of different things. We hope it could serve as an alternative for yearly checkups - as this in Norway alone could result in over 4 million checkups. As the government might be a bit hard to convince, we've also swayed into the domain of life insurance policies, and perhaps getting bonuses here. This is why this article is so interesting for us. There seems to be a focus in Germany, on the responsibility one has on his own health. Schmidt refers to; "*Article 65a SGB V permits providers of statutory health insurance to offer bonuses for those who take an active part in a range of primary and secondary prevention measures. One may qualify by taking part in age related checkup programs[...] These may include attending dieting, smoking cessation, or yoga courses. Some sickness funds also accept active membership in a sports club as evidence of efforts to maintain one's health.*"[5] The quote is actually very interesting for us, as it shows that by law insurance companies can offer incentives. You can prove your efforts to maintain your health, and thereby get rewarded. One can only but wonder why this is not a thing in Norway already. The rewards in Germany take many forms, but seem to mostly be focused around points one can earn - and trade in to items or money. I refer again to the article; "*a 45-year-old person living in the western parts of Germany, [...] can save 6.97% of monthly contributions (or € 5.83) by demonstrating that indices such as body mass index (BMI), blood*

pressure, blood sugar, and cholesterol are in an acceptable range over a period of at least 1 year" [5]
We believe this to be an excellent incentive for healthy living, and are inspired greatly by the Germans. 7% of ones monthly salary can be a lot of money, and there is definitely room for data generated by our idea in this scheme. If a membership to a sports club is enough, then surely the data one could provide with these shoes would be more than sufficient to quality as validation.
It is funny and enlightening to read that tough exercise and vegetables - with some other measures, can give around 14 years extra to your life expectancy, but that they can not actually prove that this makes the system save any money. A test they referred to in this article even showed that the healthy individuals cost more than the non healthy[8], but that the obese category was not too far from it. There is however constant debate on this, and one does not know if the healthcare provided over the extra 14 years is actually close to that provided over a shorter duration for those with a unhealthy vantage-point. The treatment given to the unhealthy could just be concentrated over a shorter amount of time, but actually accumulate about the same expenses as for the healthy.
The information from this article is sure to be used in an interview with a representative for the insurance business or the healthcare area when a representative has been found.

3. The case (Prototype)

This was initially going to be a thought-experiment. A tangible prototype was never really the goal. To come up with new exciting concepts, we wanted to keep it somewhat theoretical. Operating without a prototype enables us to easily mold, and make drastic changes to the concept, as we learn. A tangible prototype is not our main focus as of right now, but if we were to make one, we would have all the groundwork and research done to cover the basic concept. We at least know a bit more about how people move around while interacting with mobile technology, and a little bit about what has been thought of before as well, and if it worked or not. As far as our research shows us, the technology is not yet on the stage it needs to be, to be able to harness the energy effectively. A tangible prototype is therefore not feasible, as of now.
In our imaginary prototype, the harnessing of energy would take place in the sole of the shoe, with wireless energy-transfer between shoe, battery, phone and the likes. An app would be made to be able to record the amount of kilometres run, the amount of energy harnessed, etc. Maybe we would even put in a reward-system, Facebook-like system or ranking for social fun-times later on, as well. This would be included in future work. Tax- and or insurance-deduction would also be a great incentive for those who usually wouldn't be outside enjoying nature and fitness.

4. Research methods

In order to find out what research has been done on similar subjects in the past, we have conducted a literature review. A literature review has been defined as the use of ideas in the literature to justify the particular approach to the topic, the selection of methods, and demonstration that this research contributes something new [7]. We did this to put our own research into a larger context, and to learn from what others have done.

In order to understand our demographic, we conducted passive observations of outdoor enthusiasts in various locations. We gathered data about the recreational habits, approximal age groups and quantity of people jogging or walking at the locations we were observing. Notes were taken.

In order to structure our ideas and get a better understanding of what this technology can potentially be used for, we conducted a “Future Workshop " (FW). We conducted this by gathering four participants and the FW leader and divided the process up in three phases. These phases were: the critique phase, the fantasy phase and the realization phase. The fantasy phase were divided into two sections, one for potential uses of the data generated, and one for the power generated. We divided a whiteboard up in the phases, and used distinctive colored post-it notes to fill the whiteboard with the ideas we came up with. We did conduct the phases sequentially, but we also allowed jumping back and forth between phases.

In order to investigate whether a shoe that records the amount of walking and running activity of the wearer could be of interest to life insurance companies (as proof of good health) , we will conduct an interview with an insurance firm in Norway. Our Interview will be conducted in a Semi-structured fashion. This means that we will set up some broad parameters to a relatively unstructured discussion [6]. Having a less structured discussion, will hopefully encourage the interview going in unforeseen directions, and leading to us getting information that we could have not thought of asking about on our own.

5. Findings

This chapter presents the findings from the methods described in the previous chapter. The chapter starts with the result from our initial observation of people’s outdoor activities followed by the results from the future workshop we conducted with four participants.

5.1 Observation

During the course of our observation of people's outdoor activities, we observed the following activities that would be of interest to our project.

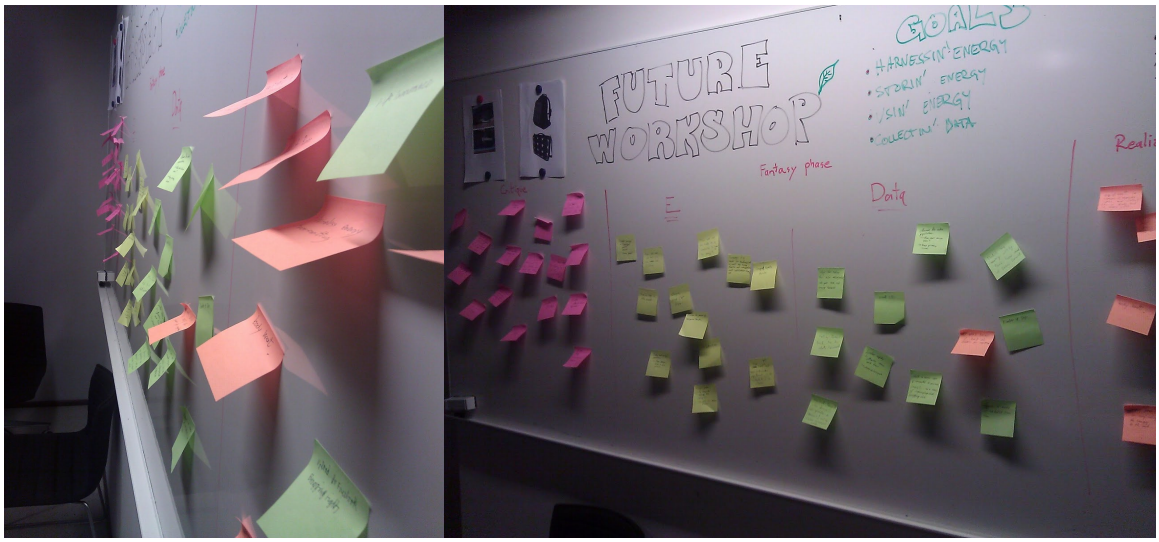
- People were jogging and running. Of course, from this activity, the devices described in [3] and [4] can possibly be used to generate the electrical energy.
- People usually have backpacks with them. We believe that these backpacks could be a place to implant some specific equipments to generate energy (e.g. Solar backpack)
- We also found many people running with their dogs and running in groups. Based on these findings, an electricity generating device could be placed to these pets. This is also aligned with one of the results from the future workshop (please see more detail in the next section).
- A parent with a baby carriage
- Roller skiing.
- Bicycling
- Traveler dragging their baggages

For the last four activities, we think we could use the small dynamo attach the wheels to generate energy. Maybe we can use wind power to generate energy as well.

5.2 Future workshop

This section describes the result we got from our future workshop with four participants. At the start of the meeting, we showed our participants some sample pictures of the current technologies that could be used to generate energy.

After that, we told them briefly about the purposes of our project and possible applications of the technologies before starting the critique phase of the workshop.



Picture from our future workshop with participants

5.2.1 Critique-Phase

In the critique phase, the participants pointed out these potential problems:

Discomfort caused by wearing the electrical energy generator device

The device that embedded in shoes needs to be more comfortable for running and should not be too heavy and clumsy. The device should also looks nice and fashionable when they are integrated to the shoes.

Technology limitation

There were a lot of comments and question about the limitation of the technologies. For example, the technologies we showed seem to be easy to break. A participant also thought that the devices could only generate a small amount of energy, and they curious about the way to store the energy for later uses.

Issues about adaptation to different environments

The technology such as a solar backpack may not be useful in the winter time in Norway because the daytime is very short. These technologies should be able to be used in harsh conditions, e.g. very cold weather in winter or being water proof.

Security issue

There was also a question about how to identify the owner of the generated energy.

Other

Apart from the categories above, a participant also mentioned their concerns regarding how to motivate people to use the technology and the feasibility to make them as the commercial products.

5.2.2 Fantasy-Phase

In this phase, participants helped each other to generate ideas without concerning about current reality. Then, we used the ideas generated from this phase as the basis for the Realization-phase which will be explained in the next section.

5.2.3 Realization-Phase

This is the phase that we came down to the reality. The realistic solutions for the problems from the critique phase can be categorized as follows:

How to generate the energy

We agreed that it's seemed feasible to have an embedded device in shoes and use it for generating data. The heat energy from the PC, engines in motorcycle are also a good source of energy.

Energy transmission

We thought that wireless transmission was the best and the most convenient solution to transmit energy from the generator directly to a device (consumer) or a storage(e.g. battery).

Usages of the generated energy

We agreed on the following uses of energy generated from the technologies:

- Using it right away after it generated, e.g. charging cell phone while running
- Selling harnessed energy to the state
- Use the data to get life insurance discounts
- Upload/share data to social media like facebook or twitter. This could motivate other people into our project as well.
- Use the amount of stored energy as an evidence for tax deductions

6. Future Plan

Currently, this is the future plan of our project.

1. We've contacted insurance companies to see the feasibility of using the data that the shoes can produce for the deduction of life-insurance payment, but we still haven't been successful in establishing a line of communication with them. We hope to get a response from them and conduct interview sessions with them in the near future.
2. Study to find out what amount of energy that is generated by each device in order to simulate the real use case.
3. Create different simulated scenarios (theoretical prototypes).
4. If we have more time in our project, we will investigate about the effect of social media, which could help spreading the values of our project to a wider public. For example, what will happen if participant sharing the statistic of energy they can save with their friends? Can this "thinking

green" value spread out to the public via the help of social media?

5. Test simulated scenario with some participants in a workshop.
6. Analyze the result from the workshop.
7. Look in to current systems like the Nike+ (http://www.nike.com/no/en_gb/c/training/nike-plus-training) or the Addidas MiCoach (http://www.adidas.com/us/micoach/)

References

[1] Paul D. Mitcheson, Eric M. Yeatman, G. Kondala Rao, Andrew S. Holmes, Tim C. Green: Energy Harvesting From Human and Machine Motion for Wireless Electronic Devices, IEEE ,Vol. 96, No. 9, September 2008

[2] Joseph A. Paradiso, Thad Starner: Energy Scavenging for Mobile and Wireless Electronics, *IEEE CS and IEEE ComSoc*

[3] Nathan S. Shenck, Joseph A. Paradiso: ENERGY SCAVENGING WITH SHOE-MOUNTED PIEZOELECTRICS: 2001 IEEE

[4] J. Kymissis et al.: Parasitic Power Harvesting in Shoes, Second IEEE Int'l Conf. Wearable Computing, IEEE CS Press, Los Alamitos, Calif., 1998, pp. 132-139.

[5] Schmidt, Harald: Bonuses as Incentives and Rewards for Health Responsibility: A Good Thing? Journal of Medicine and Philosophy , 33 : 198 – 220, 2008

[6] Crang and Cook 2007, Doing Ethnographies, Chapter 5.

[7] Hart, Christopher(1998), "Doing a literature review: Releasing the social science research imagination",London, UK: Sage Publications.

[8] Rhodes, Bradley J. Minar, Nelson and Weaver, Josh "Wearable Computing Meets Ubiquitous Computing: Reaping the best of both worlds". MIT Media Lab 1999.