Australian National University

Recommendation of Automatic Folded & Attachable Wheelchair Umbrella

Engineering System Analysis (ENGN2226)

[Inclusive Design]

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Abstract

In this project the main client is Susi, an adult wheelchair user with a mental and physical disability, and her assistants. The purpose of this project is to recommend a possible solution to using a wheelchair in rainy environments. The recommended design is an automatic folded & attachable pop up umbrella system that is an integration of multiple exiting solutions. The analysis of the dimension of the deign has been conducted using *ANSYS* software. System analysis tools have been used to analyze the feasibility of the design.

1.0 Introduction

The main client of this project is an adult wheelchair user named Susi who has mental and physical disability. Susi and her assistants often struggle in the rain, with an umbrella covering either the assistant or Susi. In this current process, protection from the rain and/or wind is inadequate and needs to be improved.

The design outcome of this project is an automatic folded & attachable wheelchair umbrella that will ensure coverage of both the wheel chair user and the assistant during the bad weather. The design outcome is easy to use and affordable for the consumers.

2.0 Problem

People who use wheelchairs often struggle in wet weather conditions. Insufficient coverage as well as equipment malfunction plague users of wheelchairs as well as their assistants. Currently Susi, the client of this project, struggles particularly as she is being transferred from car to wheelchair in this environment. Designing a shelter that covers Susi, and the person who assists her, while it is raining is the main focus of this project.

3.0 Research Methods

3.1 Research Question

A research question has been used to narrow the scope of this project. From the theme of making life easier for Susi, we were told explicitly that there are issues with keeping her dry in poor weather conditions while traveling. We then focused in on umbrellas specifically as a design team we believed we can provide an easy solutions than other alternatives available in the market. As such, our research question became; "How can umbrellas be used to ensure that people with disabilities, as well as their assistants, remain dry in poor weather conditions." It is this problem that the design team tried to solve with this design.

3.2 Surveys and Interviews

A small interview and a Q&A session with Susi's assistant were conducted during Dlab6 of ENGN2226 course, as part of the research procedure. The questions were asked during the interview has been included in the Appendix. From the needs and wants claimed by Susi and her assistants, in regards to the wheelchair design, the design team determined a few design requirements. The requirements are mentioned below:

- Protects the wheelchair user and the assistant from the rain.
- Must be able to travel with the user and assistant.
- The design must be easy to carry.
- The design must not impede the usage of the wheelchair
- The design must be simple with no specialized training required for it's use
- This small change leads to a big result (a high leverage solution)

3. 3 Data Organization

All the requirements data gained from building the research question and interviews and Q&A sessions were organized into different categories, in order to make the design procedure easy. There were requirements regarding the dimensions of the wheel chair influenced by the height and weight of Susi. Moreover, the dimension requirements were obtained by the physical mechanisms of the design, for example, gravity and the air resistance of the umbrella. Some of the information acquired from the interviews and the

crafting of the research question were included into the features category of the wheelchair, which includes the design of the umbrella and the fixing mechanism of the wheelchair.

The data was organized as follows:

- Dimensions:
    - Influenced by Susi's appearance
        1. Height of wheel chair
        2. Weight of wheel chair
        3. Width of wheelchair
    - Influenced by physical mechanisms and features of the wheelchair and the carer's height
        4. Weight of the umbrella
        5. Height of the umbrella
        6. Width and length of the umbrella's canopy
- Wheelchair features
        5. Thickness of the wheelchair's tires
        6. The specific design of the umbrella's canopy (see Figure 1 & Figure 2)
        7. The folding mechanism of the umbrella
        8. The adjustment mechanism of the umbrella
        9. The design of the wheelchair's seats

4.0 Solution: (Key Features of the New Design)

The final solution is the automatic folded & attachable pop up umbrella system that has been created by integrating several existing solutions. The umbrella system can be divided into three different subsystems; the dimensions, the automatic folding operation mechanism and the attachment mechanism.

4.1 Description of the Dimensions

To develop the product, the design team considered the customer requirements recorded during the interview. Client expectation of the product is to provide shelter from rain/wind and, at the same time, be convenient to use and to handle.

The main focus is given to particular dimensions in designing automatic folded & attachable umbrella system. Those dimensions are height of the product when it attached to the wheelchair, width of the umbrella and the weight of the overall product.

An automatic folded & attachable umbrella is designed to be high enough to accommodate a person of average height and give extra space if need for movement in vertical direction such as lifting hands. Also the product has specific shape in form of elongated umbrella to protect both users from the rain and at the same time wide enough to protect them from the wind (compare to conventional umbrellas), see *Figure 1&2*. Although, these dimensions are drawn from available data on human anthropometrics, a three dimensional prototype should be constricted and verified against a three dimensional human model.

4.2 Automatic Folding Operation Mechanism

The automatic folding umbrella will include a main rod, canopy supporting umbrella ribs, a slide element and a handle. At the tip of the rod the umbrella ribs are pivotally installed. Under the tip of the main rod the primary link rods are installed [Multi-folded full-automatic opening-closing umbrella, 2014]. Corresponding umbrella rib and each primary link rod are coupled using a secondary link rod. The main rod also holds the slide mechanism, and the handle installed at a bottom end of the main rod holds a link mechanism [Ni, 2014]. A diagram of this set-up is included in the Appendix as *Figure 3*

The main rod includes a link element and a link mechanism coupled to the slide element. Elastically stretchable elements couple the slide element with the primary link rod. The link mechanism is driven by the link element to slide the slide element. The elastically stretchable elements are pulled to drive the primary link rods to unfold or fold the umbrella ribs [Chang, 2014].

This will allow the umbrella to fold out like a normal umbrella but with a few small differences. Due to the geometry of this umbrella, the folding mechanism will consist of an extra set of ribs on one side of the umbrella. This will allow for the automatic deployment of the umbrella and allow for one side to be larger than the other. A diagram of the umbrella folding mechanism is shown in *Figure 4* of the Appendix.

4.3 Attachment Mechanism

The attachment of the umbrella is supposed to be stable and easy to install.

In our design, the umbrella is attached to one handle of the wheelchair by the 'Quick release mechanism' *Figure 6* [Annette, 2015], which is inspired by the adjustment of bicycle seats. As shown in *Figure 5* in the Appendix, the attachment mechanism can be folded at the bottom of the umbrella when not used. When it's rainy, the user just needs to unfold the mechanism, and attach the umbrella to the wheelchair handle by 'Quick release mechanism'.

4.4 Expected use:

According to BOM on average Canberra experiences 108 rainy days per year. Therefore, this given time period should be considered the absolute maximum of yearly usage.

4.5 Costs

Costs have been minimized though the use of easily manufactured dimensions as well as widespread, cheap materials.

Aluminum is a low-cost metal that is used for many appliances of mass production. Therefore, the pole and the frame of the umbrella is made of aluminum.

The waterproof material of the umbrella is a cheap canvas that is in high quality and high benefits.

5.0 System perspectives

5.1 Safety & risk

The challenges are to find equilibrium between the product being too light and being too heavy. Each feature has its own benefits, such as, when the product is heavy, it can be used as additional support for the client while standing, and when the product is light, it will be easy to transport, carry and to install. But also those features are possible hazards such as disrupting the wheelchair balance/the center of gravity or moving/unbalancing in the event of strong winds.

While opening and closing the product. Recommendations of use (such as safe distance) for client /care person, and care person should be always aware of the safe distances while operating the product.

Product should be compliant with Australian Standards which ensures that "...products, services and systems are safe, reliable and consistently perform the way they are intended to" [Novitatech, 2016].

Independent and professional test can be conducted/performed by non-for-profit, accredited National Association of Testing Authorities (NATA) organizations such as Novitatech [Novitatech, 2016]. Novitatech testing organization and its branch Novita's Assistive Technology Service (ATS) specializing on assurance of safety, quality and reliability of the products which are designed for people living with disabilities.

Design prototype can be send to ATS in South Australia to be tested for quality and safety to ensure the product is fit for purpose. Although, the initial cost of the prototype will increase (note: the tax concessions are applied for R&D products), the overall cost for a mass manufactured safe and risk-free product will be worth it.

5.2 Anthropometrics

The need to understand anthropometrics crosses many technology interfaces (Wheelchair Measurements, 2016). Anthropometrics refers to human measurements being taken into consideration when designing a system. Our system in this problem consists of 2 human beings. First person being the subject on the wheel chair and second one is the assistant. The height of the umbrella is designed such that it can fit a human subject that is 2.25552m tall (Height of wheel chair+ height of umbrella = 0.76+1.5m=2.26m) [Australian Bureau of Statistics, 2016]. According to Australian Bureau of Statistics 220 people out of 7296 had a height greater than 190cms (approximately 0.0301), this covers over 99.969% spectrum of human height range. The width of the umbrella is 1.33m at the widest point [Wheelchair Measurements, 2016]. This was chosen by taking into consideration the average width of a wheelchair that is 0.76m.

5.3: Material Impact Perspectives

The pole and wire frames are to be constructed from aluminum because of it's light weight as well as low-cost. The umbrella fabric will be some sort of plastic for the same reasons. This low-weight will also allow the product to reach a wider market as it will be cheaper to transport.

By utilizing commonly used dimensions for the pole and the wires, manufacturing the device should be made simpler and cheaper. These well-known dimensions should be in stock in a lot of places, which will make them cheaper to purchase and use in the design.

Both the materials and the dimensions have been selected in an attempt to minimize the product life cycle cost so that consumers can feel like they have spent their money well as soon as possible (Ilan & Ilan, 2013.)

A material audit has been conducted and supplied as *Table 1* in the Appendix.

6.0 Key Benefits:

Some of the key benefits of this design are:

- Light and convenient to use
- Umbrella geometry minimizes wind loading while maximizing coverage (according to BOM Canberra experiences on average 25 day per year of strongest winds) (Bureau of Meteorology, 2016)
- Small size (can fit in car) and easy to carrying
- Can be opened and closed automatically by push-button operation [Australian Competition and Consumer Commission, 2016].

7.0 Conclusion:

The system aims at providing a fair and a relatively economic solution to the problems encountered .The system is designed by focusing on factors such as portability, ease of operation and utility. There are some areas that need to be worked on for the design to become optimal. They are:

- Increase umbrella stability during wind conditions
- A proper investigation and design for the automation operating system.
- Sources for the materials as well as producers for manufacture.
- A way to sell and distribute the product.
- A detailed description of the attachment system
- Type of material of the umbrella is a waterproof material. So, after usage, the umbrella would be mostly dry. Though, it is not 100% guaranteed that the material would resist water for the given period of warranty, due to the case that water might still be on the umbrella in drops form after rain.

Reference

[1] Australian Competition and Consumer Commission (ACCC), 'Product Safety Australia', viewed 10 September 2016. http://www.productsafety.gov.au./

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[3] Chang, S., Shengjing Technology (Shenzhen) Co., Ltd., 2014. *Guy structure for an automatic unfolding and folding umbrella*. U.S. Patent 8,800,576.

[4] Chen, W.O., Lin, M.P., Yeh, C.W. and Chen, H., 2014. *Multi-folded full-automatic opening-closing umbrella*. U.S. Patent 8,757,184.

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[8] Ilan, N. and Ilan, U. 2013. Motor operated wheelchair Umbrella. U.S. Patent 8,387,641.

[9] Table 14: Height by age and sex – Australia Released 07/06/2013 at Australian Bureau of Statistics. Viewed 16 September 2016 http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4364.0.55.0012011-12?OpenDocument

[10] Wheelchair Measurements. Suntran.com, 'Welcome to Sun Tran - Tucson, Arizona', viewed 16 September 2016. http://suntran.com/pop_access_measurements.html

[11]Figure 6:An example of 'Quick release mechanism' http://hdimagelib.com/pipe+clamp?image=348713189

[12]Bike Seat Adjustments – Height, Tilt and Reach. By Annette. 2015 https://www.goride.co.nz/portfolio/bike-seat-adjustments/

Appendix:

Figure 1: Top view of the umbrella drawn using ANSYS.

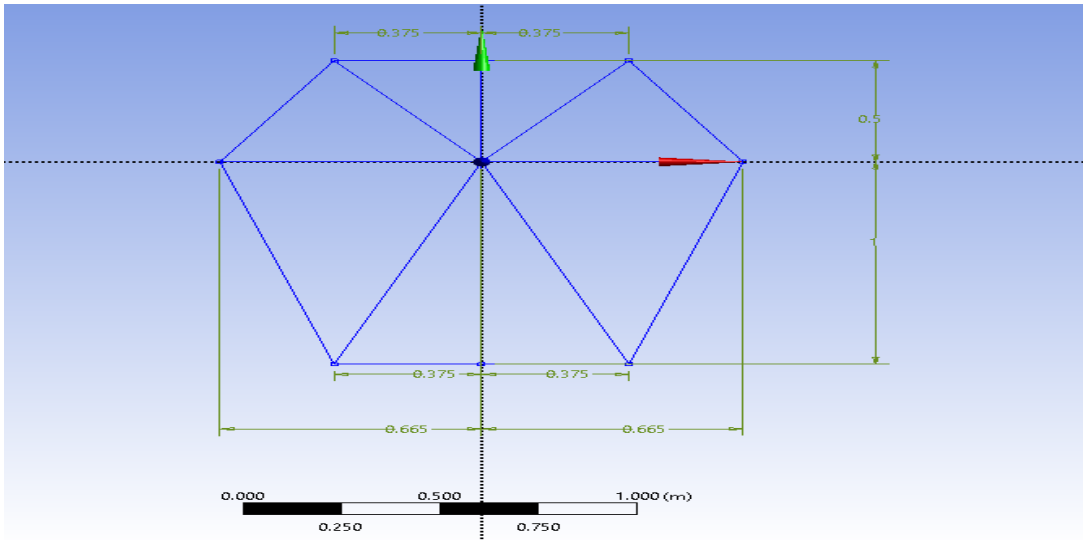

Figure 2: Left view of the umbrella drawn using ANSYS.

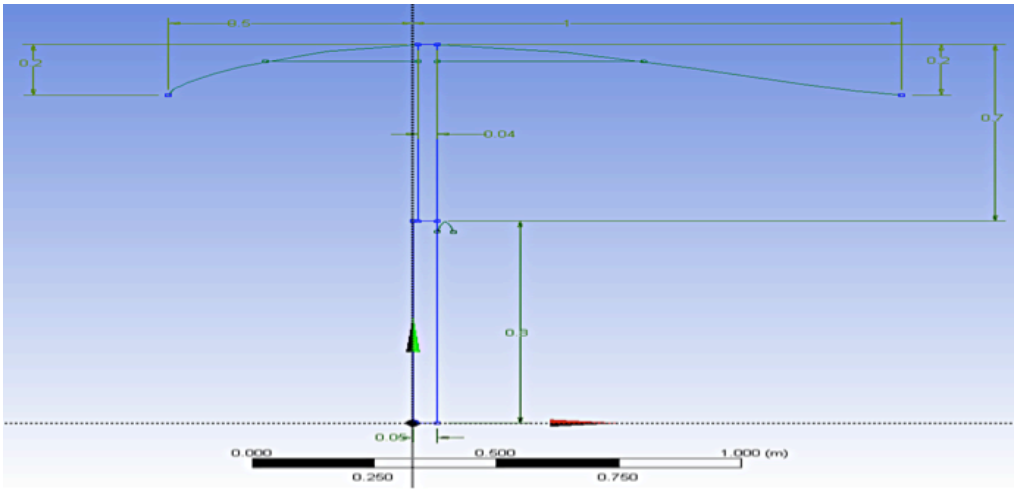

Figure 3: Automatic Operation Folding Mechanism

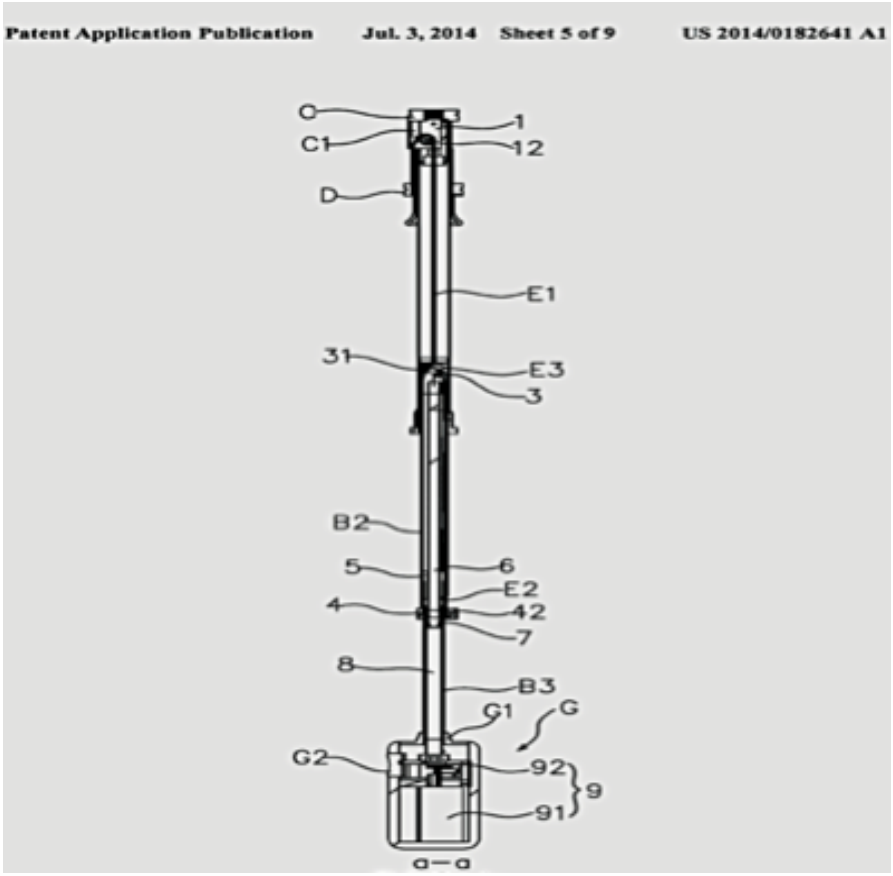

Figure 4: Umbrella Folding Mechanism

[https://au.pinterest.com/pin/225743000048128165/]

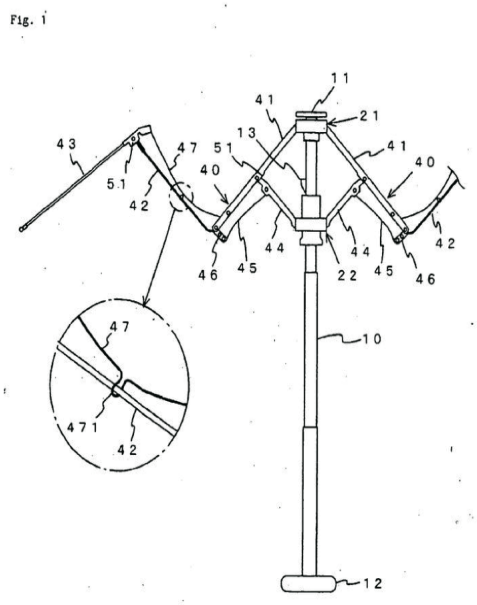

Figure 5: Attachment Mechanism

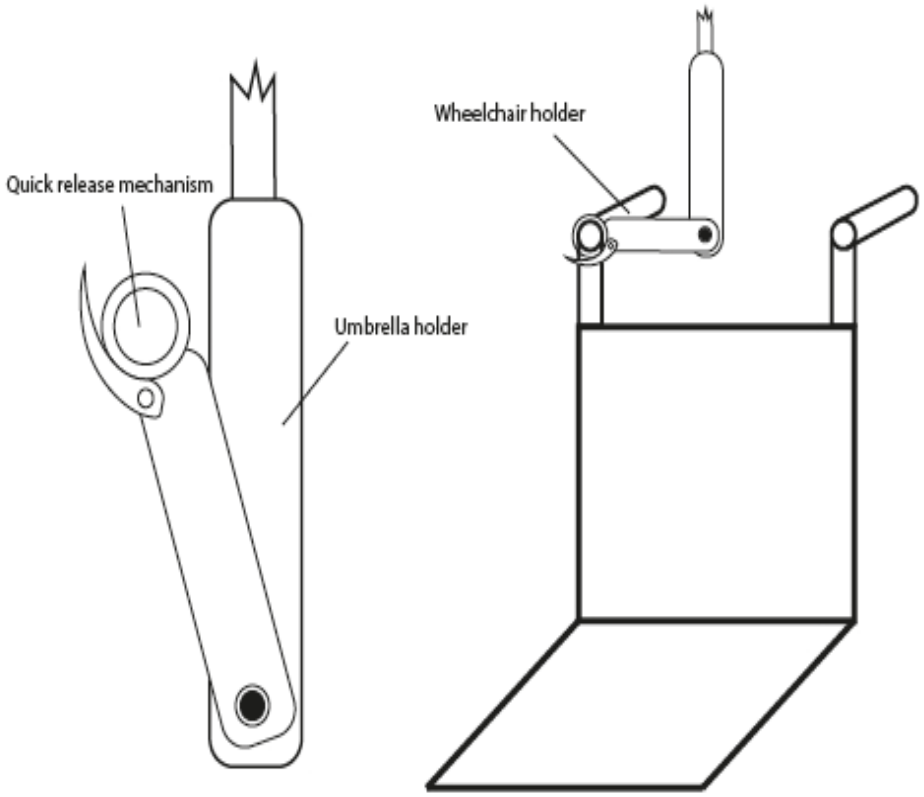

Figure 6: An example of 'Quick release mechanism'

[http://hdimagelib.com/pipe+clamp? image=348713189]

Table 1: Material Impact Perspective Table

Part	***Material***	***Quantity***	***Mass***
Umbrella	*Nylon 66*	*1.5 X 1.33 X 0.001 m*	*2.29 kg*
Pole	*Aluminum 6061*	*1.5 X 0.05 m*	*3.055 kg*
Ribs	*Aluminum 6061*	*5 X 0.01 m*	*0.01 kg*
Total			*5.355 kg*

NOTE: The Attatchment mechinism and the Automatic Operation Folding mechanism are not included. These values are an approximate measure .