Walter – A Wheelchair with an Alternating Center of Gravity Designed for Developing Countries (Chalmers University of Technology)

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Walter

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Abstract

This project was initiated to develop an adult active manual wheelchair compatible with the social, physical and economic conditions that currently characterize the situation in the growing semi-urban environments in developing countries. The new wheelchair design should promote an increase of independency and ultimately social integration of wheelchair riders in this context.

The project was characterized by a four-step process including initial research in Gothenburg (Sweden) functional prototype development with *Whirlwind Wheelchair International* at their headquarters in San Francisco, field trials in Yogyakarta (Indonesia) in collaboration with *UCP Wheels for Humanity Indonesia* and finally development of the second and final prototype in Gothenburg. The inclusion of previous studies from a wheelchair project in Kenya means that the end result is based on information from four different continents.

The final design has an alternating seat, which enables two different center of gravity positions. Altering the center of gravity forwards means a facilitated situation when riding steep. The front position also makes it easier to perform a lateral transfer when getting in our out of the wheelchair. These advantages contribute to increase the level of independency among the intended user group and thereby promote an increased level of social integration.

YouTube video at http://youtu.be/iAEtcKDyabA

Introduction/Background

The rough terrain in developing countries causes many wheelchair users to be very dependent on assistance. Many wheelchair riders are also unemployed and this alongside with the difficulties to independently manage everyday life situation results in many users being isolated in their homes (Loeb 2008; Eide 2009). The background of this project is formed around current wheelchairs designed for usage in developing countries. These are generally bulky and heavy, which is ungainly both considering maneuvering procedures and when being lifted on top of buses or in cars for transport. They are designed to withstand rugged terrain and a tough usage, and the requirements on keeping costs low forces an extensive usage of steel according to its terrific durability to cost ratio. This, however, increases the weight and ultimately aggravates these transport procedures. The possibilities to become independent is thereby inhibited by social factors, as unemployment and a lack of acceptance in the society, but also by wheelchairs designed to accommodate external requirements but not always considering the social situation of the users.

There is a need for a wheelchair with emphasis on user-centered design for riders in developing contexts. The new design should hold some characteristics of current developing world wheelchairs, such as long wheelbase and wide front castors to withstand environmental factors. However, a number of challenges remain to be solved. How can an appropriate expression for a wheelchair in this use environment be found and in what way should it provide comfort of the user and ensure his or her contribution to the society? Furthermore, the price of the wheelchair is of crucial importance, both in terms of initial purchase and maintenance. Hereby, keeping the costs low for manufacture and spare parts is necessary.

The idea is to provide an adequate assistive product solution that will help to generate an additional degree of freedom and facilitate social integration. Such solution may particularly include improved access to local public transport, which could counteract the tendency of people getting isolated in the society due to a potential impairment. Is it possible that people dependent on wheelchairs will experience a significant elevation in self-confidence and tangibly perceive a personal contribution to the society? Incapabilities related to disabilities would in such case be decreased and also provide greater possibilities for personal development.

Problem Statement

The project aim is to design an adult active manual wheelchair, which is compatible with the social, physical and economic conditions that currently characterize the situation in semi-urban environments in developing countries. Part of the project aim is also to offer a wheelchair design that is currently not available to users in these contexts, which will serve to increase the capability of providing customized wheelchair solutions for a comprehensive range of use scenarios in developing countries. In the longer perspective, this should become beneficial for the intended target group.

This is accomplished by addressing the following questions:

- How should a wheelchair be designed to increase the opportunities for social integration for active wheelchair riders in semi-urban environments in developing countries?
- In what way should a wheelchair be designed to differentiate from current products on the market?
- Regarding the current market situation, how could a wheelchair be designed to promote innovative wheelchair development in developing countries, which ultimately would foster an industry modernization?

Methods/Approach

The Walter project has included wheelchair expertise all over the globe through a four-step process with distinct geographical phases. The first phase included planning and initial research in Gothenburg, Sweden. This phase was primarily characterized by literature studies and meetings with Swedish wheelchair

developers and occupational therapists. The second step was conducted together with Whirlwind Wheelchair International, a non-profit social enterprise dedicated to develop wheelchairs for users in developing countries, at their headquarters in San Francisco, CA. They provided access to expertise and resources for designing, constructing and building a functional wheelchair prototype. This prototype was then brought to Yogyakarta, Indonesia, for the third phase. Field trials and user studies were conducted together with UCP Wheels for Humanity Indonesia, a non-profit Yogyakarta based NGO. The fourth and final phase took place in Gothenburg where the feedback from these studies was translated into user requirements and technical specifications, which formed the base of the final result – a new wheelchair designed to accommodate the needs of wheelchair riders in semi-urban environments in developing countries. The methodology implementation was also complemented by a previous wheelchair project at Chalmers University of Technology conducted by Christian Bremer, Erik Ohlson and Marika Olsson. The result was a proposal on a new kind of wheelchair distribution system and a conceptual wheelchair design for children with disabilities in Kisumu, Kenya. This means that the final result is based on personal experiences and input from four different continents.

The initial idea was to overcome these challenges by designing a lightweight wheelchair for developing context. The project, however, took an interesting turn when the center of gravity translation was discovered. This construction is more complex than a rigid framework with a fixed seat, which leads to a somewhat heavier and slightly more expensive solution and the user studies showed that not all users are in need of an alternating seat. A lightweight rigid frame chair should therefore be further considered but the innovative aspect of an alternating seat together with a long wheelbase wheelchair made it very interesting for further development. The field studies confirmed the advantages of the new seat solution and showed that it can possibly be very beneficial for paraplegic users and amputees according to their different problematic of overcoming steep slopes.

Result

Walter is a rigid frame, active manual wheelchair that enables the user to temporarily translate the seat 100mm forward to alter the center of gravity (COG). The primary purpose of this functionality is to prevent the user from

falling backwards as the handrims are firmly pushed in order to climb heavily inclined slopes. According to user evaluations, changing the COG becomes particularly beneficial for paraplegic users who are unable to control their upper body using abdominal muscles, but may also address the needs of a double leg amputee who have a very small weight distribution over the front casters.

When moving the seat to the front position, the side protective fenders will maintain a backmost position which ultimately will generate a large transfer window (Figure 1) and consequently contribute to facilitate an independent transfer. The seat alternation procedure is easily accomplished by using the levers to push the seat forward. As some users may accomplish the alternation without using the levers or may prefer to use a seatbelt which constraints the seat to follow the body movement, the levers are also *detachable* to accommodate variations in the users' level of experience.

Figure 1 - Seat alternation

Figure 2 - Backrest lock to facilitate pushing assistance if present

The chair is made out of steel and primarily bicycle components, which ensures manufacturability and reparability in the developing context. There are no exact calculations on the actual manufacturing costs for this wheelchair proposal but a general discussion can be held on the expectancy of such costs. Whirlwind Wheelchair International currently develops and produces a wheelchair named RoughRider. It is a foldable chair designed to withstand the tough usage in developing countries and is currently distributed to users all over the developing world. By comparing the RoughRider to our proposal, it can be seen that the manufacturing complexity is very similar. This means that by estimating the costs, it can be assumed that the cost of producing Walter should be similar to producing the RoughRider. Both chairs have similar framework designs, similar material choices and a moving construction placed under the seat.

Figure 3 - RoughRider/Walter comparison

Discussion

Even though the final prototype appears as a final product, there are several iterations left before this solution could be fully introduced to the market. The design is based on user feedback but further empirical studies should be implemented, and the chair should be evaluated through studies where riders are using this chair for several days or weeks to demonstrate undiscovered shortcomings. There is also a need to include mechanical engineers and constructors in the coming development process to optimize the solution regarding weight and cost. Some detail solutions may be replaced to decrease the manufacturing costs and to lower the total weight of the chair.

Conclusions

The final result is a new wheelchair concept, developed for semi-urban environments in developing countries. It has been developed considering the current situation in semi-urban environments in developing countries and is seen as a contribution to social integration for suitable users according to that it provides necessary functionality to let these users overcome obstacles they currently cannot independently manage.

The alternating seat alongside with the rigid framework implemented through this project is definitely seen as a differentiation from currently available solutions on the market, which may have an competitive advantage. This enhancement is not only due to the final concept but also the insights regarding the prospect user group. This study provides information that could be used to

further develop current and future products for disabled people in developing contexts.

By basing this final design on a rigid framework, which is currently successfully used by several wheelchair developers in industrialized countries, there has been a technology adaption from an industrialized context to a developing context. As this technology has enabled new technical opportunities, it has been possible to introduce and evaluate new and innovative wheelchair solutions. Building the alternating seat based on the industrialized version of the frame and proving its user benefit, demonstrates a distinct example of the inherent potential for both modernization and innovation in the developing world.

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This project can be viewed at http://aac-rerc.psu.edu/wordpressmu/RESNA-SDC/