On the Design of High Quality Sensorised Modular Strollers

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***Abstract*— This proposal introduces *StokkeWorks*, a virtual and physical rapid-prototyping framework that allows for the simulation and optimal design of high quality sensorised modular strollers. By combining the rapid-prototyping approach with the modular concept, different stroller configurations can be modelled. A one-to-one correspondence between virtual and physical prototypes is established.**

By using a low-cost sensing approach, functions for force and torque sensing at the axle level, sensitive collision detection and effort monitoring are possible. Moreover, a Global Positioning System (GPS) sensor and an accelerometer are used to monitor the route, elevation and milage. Other sensors such as temperature sensors, microphones, etc. can be employed. Some of these sensor data can be used during the design phase to find the optimal design for the prototypes according to specific requirements. In addition, during the operation phase, other information can be used to actively adjust some parameters (suspension stiffness, wheel friction, etc.) to the current operation scenario and to improve the user experience. Safety devices like airbags or emergency breaks can be also triggered on run-time. A 3-D visualization environment allows for an intuitive visual feedback during the designing phase, while a possible mobile application allows the user to visualise usage data and other statistics.

***StokkeWorks* introduces potential innovations in the strollers design, safety and user experience.**

I. Introduction

Building a stroller with sufficient versatility that can adapt to different requirements and operation scenarios is a very challenging task.

A promising solution consists of adopting a modular approach. The modular concept can be applied to different fields for a variety of applications. For instance, different design methods and control algorithms for modular robotic hands are presented in [1]–[3]. By using modular components and interchangeable parts, it is possible to match the stroller configuration with the specific task to be accomplished (e.g., going off road or on road). Modularity offers robustness to mechanical failures considering that the stroller parts are interchangeable. The production cost can also be considerably reduced and the weight of the stroller can be minimised. Moreover, modularity is advantageous in terms of versatility since the stroller can be disassembled and reassembled to form new morphologies that are suitable for new tasks.

From a design point of view, rapid-prototyping can be beneficial when developing modular strollers with different configurations. Development time can be significantly reduced and the quality can be assessed. Therefore, rapid-prototyping is a necessary step to validate the design before making a physical prototype.

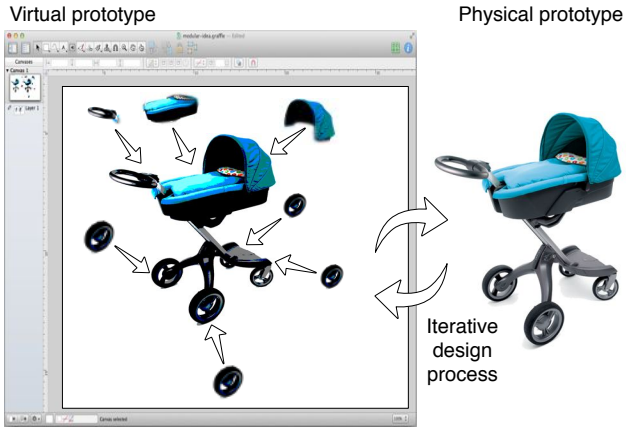

Fig. 1: The idea of realising an integrated virtual and physical rapid-prototyping framework for the design and simulation of high quality sensorised modular strollers.

In this proposal, *StokkeWorks*, a virtual and physical prototyping framework that allows for rapid-prototyping sensorised modular strollers, is presented. The idea is shown in Fig. 1. This method consists of an immersive and iterative design process that involves mechanics, hardware and software. A real-time one-to-one correspondence between virtual and physical prototypes is established. The on-board, low-cost sensors allow for evaluating the design effectiveness during the development phase. An intuitive visual feedback is also provided by means of a 3-D visualisation environment. In addition, in an operation scenario, the sensor feedback can be used for improving the user experience in terms of usability and safety. A possible mobile application can be developed to interact with the sensorised strollers.

The proposal is organised as follows. In Section II, a review of the related work is given. In Section III, the author focus on the description of the *StokkeWorks* architecture. Afterwards, some application scenarios are discussed in Section IV. Finally, the innovation factors of this proposal are outlined in Section V.

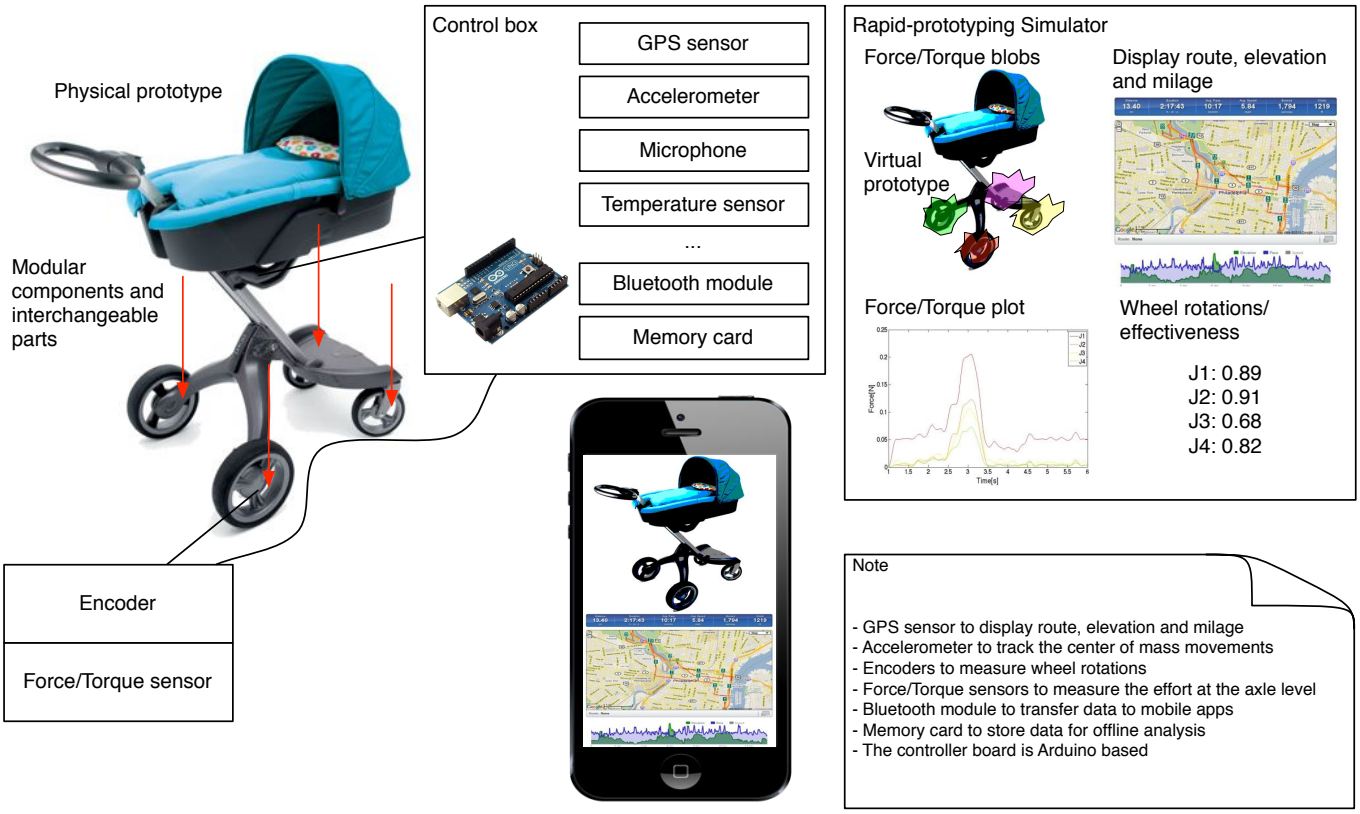

Fig. 2: The proposed system architecture for *StokkeWorks*. The sensor data is collected by the controller board and it can be stored on a memory card for offline analysis in a 3-D simulation environment or transferred wireless to a potential mobile application.

II. Related Research Work

The modular approach as been already applied in some commercial products in this field. For instance, the *Britax B-Ready* stroller is a full-size modular strollers that is appropriate from 6 months (or from birth when used with an infant car seat) up to 25Kg and can accommodate up to 2 children [4]. Another example is the *Signature Series*^{TM} *Classic Connect*^{TM} 3-in-1 modular stroller that features three different seating options [5].

However, most of these works mainly focus on the mechanical construction process, while hardware and software prototyping are often neglected in the prototyping design. To the best of our knowledge, an integrated mechanical, hardware and software rapid-prototyping framework for designing and testing different configurations of modular strollers is still missing.

Moreover, few example of integrated electronics on board of a stroller have been introduced. A company called *4moms* introduced *Origami*, a stroller that can power folding itself with the push of a button [6]. A digital dashboard that displays temperature, speed, miles covered, and whether or not a baby is actually in the stroller is also provided. Nonetheless, a wide range of possible applications have not been investigated yet.

III. *StokkeWorks* Architecture

The underlying idea of this proposal is shown in Fig. 2. A controller board of very small dimensions and weight is installed on the stroller. This controller board is the core of the system. Several low-cost sensors can be connected to the controller board as, for instance, encoders and force/torque sensors on the wheels, a GPS sensor, an accelerometer, a microphone, a temperature sensor, etc. The sensor data is collected by the controller board and it can be stored on a memory card for offline analysis in a 3-D simulation environment or transferred wireless to a potential mobile application. These data can be used for several application.

For instance, during the design process, an iterative developing approach can be used to find the most effective design for the strollers according to specific requirements. This approach is described in the flow-chart shown in Fig. 3.

In addition, the effort of each wheel axle can be monitored and optimised during the design process. To do this, a force/torque sensor is used to continuously measure the load of each wheel. Encoders are used to count the number of revolutions of each wheel and calculate the corresponding

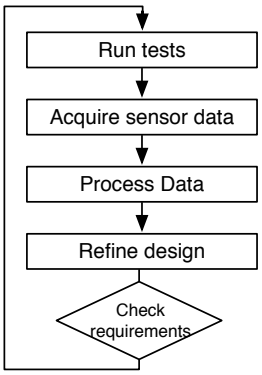

Fig. 3: The iterative approach that can be used to find the most effective design according to specific requirements.

Fig. 4: Safety devices like airbags can be triggered on run-time.

effectiveness. Moreover, in an operation scenario, crucial functions like sensitive collision detection are possible.

Other important functionalities that can be achieved in a possible operation scenario concern the safety of the baby. Safety devices like airbags or emergency breaks can be triggered on run-time as shown in Fig. 4.

IV. Some Other Application Scenarios

A sensorized model of stroller opens up to a large variety of application scenarios. The strollers become a companion for the mother or father and a safer and smarter device for the baby. A possible application, for instance, consists of using the stroller not only as a means of transport for the baby but also as a training device for the parent, which can carry the baby and do jogging in the same time, while monitoring the training section on a possible mobile application through the stroller's sensors as shown in Fig. 5.

Fig. 5: The parent can carry the baby and do jogging in the same time, while monitoring the training section on a possible mobile application through the stroller's sensors.

Another possible idea consists of using a temperature sensor to continuously check and assure the optimal temperature for the baby. An alarm signal can be triggered on a mobile application when the temperature reaches a predefined threshold as shown in Fig. 6.

A microphone could be used to monitor the baby voice and trigger an alarm on a potential mobile application so that the parent would take care of the child as shown in Fig. 7.

The possibilities for new possible applications are almost endless and new ideas can be integrated to the framework at a later stage.

V. Innovation Factors

The fundamental innovation factors of the proposed project are based on the concepts of modularity, optimal design, low production cost, safety and user experience. The level of innovation of the proposed project is promising form different point of view. From a methodology perspective, this project has to combine expertise from complementary disciplines: design, mechanics, computer science, and software engineering. All research results have a potential to effect and to fundamentally revolutionise the field of the strollers production. From an application perspective, the project will improve the technological level and productivity of *Stokke*. From a research perspective, to the best of the author's knowledge, to date there are no similar prototyping framework available in Norway, nor in Europe or in the United States. The system will feature an efficient design approach and several remarkable improvements to the user experience and safety. The project will therefore be unique

Fig. 6: The temperature can be monitored and displayed on a mobile application.

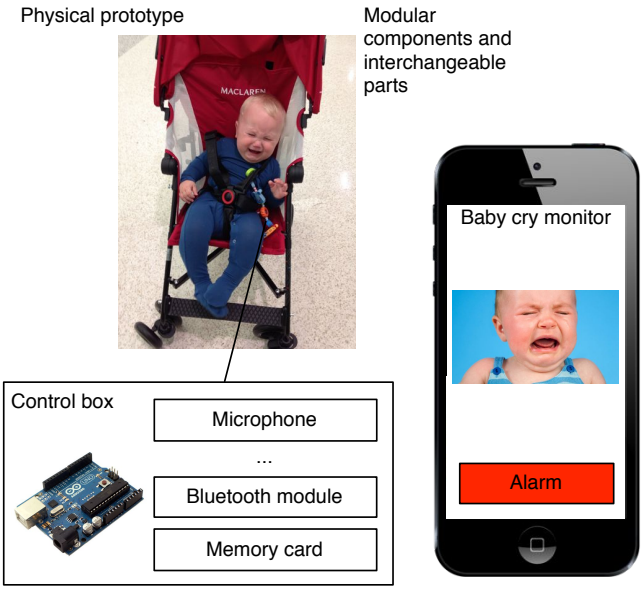

Fig. 7: A microphone is used to monitor the baby voice and trigger an alarm on a mobile application.

and it will strengthen the name of *Stokke* in the region, nationally and abroad.

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