Recommendation System for Sizing of Children's Footwear

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Abstract

Accurate footwear size is very important for healthy development of children's feet. Many foot problems are caused by wearing too small shoes as a child. Parents usually experience problems selecting the accurate size of shoes for their children, who cannot report their feelings precisely. Primitive methods for detecting the accurate size of footwear are used, like pressing on the toe box or putting a finger behind the children's heel when trying shoes. Parents don't take into account children's feet growth when buying shoes at the beginning of the season, therefore shoes are usually too small at the end of the season.
A recommendation system for sizing of children's footwear was tested with 83 parents and their children. Children's current shoes were scanned with UCS SID (Shoe Inner Dimensions) 3D shoe scanner. Parents were asked to estimate the expiration date of current child's shoes (for how many months child's current shoes will still be large enough). Children's feet were scanned with UCS SC3 foot scanner. Parents were presented a 3D visual comparison of child's foot scan and shoe scan, where child's foot was overlaid by shoe scan to show exact position of child's toes in the shoe. Child's foot scan was gradually enlarged by estimated foot growth rate to visually simulate position of child's toes in the shoe in the following months. The recommendation system suggested expiration date for the child's shoes. After this procedure parents were asked again to estimate the expiration date of child's shoes.
Majority of parents shortened the expiration date of child's shoes after the 3D visual comparison and simulation of child's foot growth. In many cases before the 3D visual comparison parents thought that current shoes were large enough, but after the procedure they realized that the shoes were too small. Majority of expiration dates reported by parents after the 3D visual comparison were equal to suggested expiration dates of the recommendation system.
Result show that such a recommendation system with 3D comparison of child's feet and new shoes would help parents selecting the accurate size. Such a system would decrease number of Children wearing too small shoes.

Keywords: 3D foot measurements, 3D shoe measurement, children's footwear, recommendation system

1. Introduction

There has been little research on effect of footwear on children's. While many of foot deformities are hereditary, improper footwear may exacerbate the foot conditions [1]. For this reason, selecting the best fitting shoe for children is important in order to prevent future foot problems. Many of such problems (hallux valgus, hallux rigidus …) [2] are caused by wearing shoes of insufficient length as a child. According to study made by Dr. Wieland Kinz, 89% of children in Austria wear too short indoor shoes and 69% wear too short outdoor shoes [3].
The methods parents use for determining the correct shoe sizes are relatively primitive and in many cases inaccurate. Pressing the toe area to get an indication of the available toe space or putting the finger behind the children's heel in order to detect the difference between the foot and the shoe, are imprecise methods used for selecting the proper shoe size. Parent's main concern is the length of the shoe, while pain or discomfort in the ball area of the foot (metatarsophalangeal joint area) is almost always associated with narrow shoe. Most fit problems are generally around the "width" dimension while the commonly used shoe sizing system is predominantly in the length dimension [4].
Footwear fit still remains somewhat subjective and is hard to quantify. There has been several attempts to develop 2D fit metric to show footwear fitting problems, but studies have shown that length

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and width are measures which are insufficient for proper fitting [5]. UCS company has developed tools for measurement of most important characteristics of both feet and shoes. The feet measurement method is fast, accurate and is suitable for children. The output is 3D geometrical model of the foot, and various characteristics may be extracted. The shoe measurement is relatively fast (50 shoes per hour) and accurate, however, it is not portable and requires considerable space. Combining both technologies, UCS has developed a child shoe size recommendation system (CSSRS), which compares 3D models of children's' feet and specific shoe models, which are selected on parents' demand. Child shoe size selection is strongly influenced by the fact that the children's' feet grow with time. CSSRS has been designed in such a manner, that it incorporates the feet geometry, the shoe geometry and the child's foot growth prediction. The result of the CSSRS is a set of shoe sizes for particular shoe model, accompanied by the "expiration" time prediction. CSSRS generally predicts 2 subsequent sizes for coming months, since suggestion of next sizes would result in excessive geometrical difference between shoe and feet.
To validate the CSSRS, UCS has conducted a research, where children and their parents were invited to bring shoes which were worn currently by children. Parents were asked to estimate the "expiration time" of brought shoes. Later they were presented by CSSRS. Their decisions before and after using the system were recorded. In the following, the methods, tools and main conclusions are presented.

2. Tools and methods

To measure the children's feet, two different 3D scanners were used. The first one was SC-3 developed by UCS (http://www.ucstech.eu/ssfootscanners.html) and is depicted in Fig. 1.a. It is an optical scanner, which is easy to use, has a simple user interface, is very fast (measurement takes only a second), and accurate (+- 1mm in length, width and girth when scanning rigid artificial foot-like bodies). The scan is processed by integrated computer and submitted to remote central database to be available for further analysis or matching process.

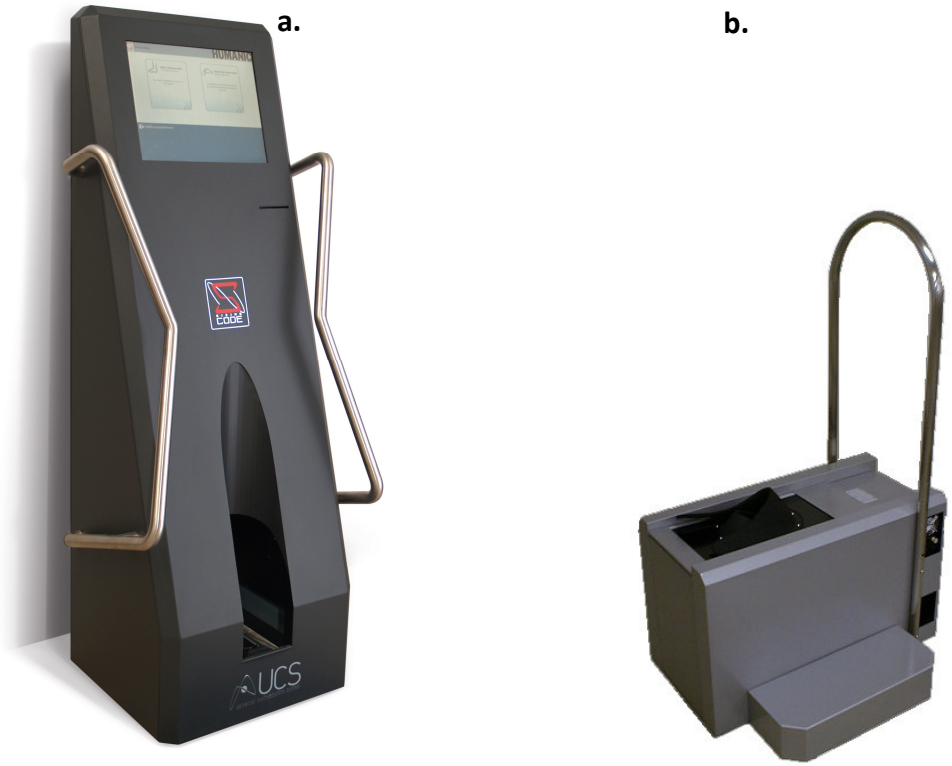

Fig. 1: SC-3 foot scanner and INFOOT High Type scanner

We additionally used the INFOOT scanner (see Fig. 1.b). The disadvantage was the long scanning time (15 seconds each foot), so in many cases we were not able to scan small children. The resulting data has been converted to a compatible format and uploaded to central database.

The shoe inner surface geometry measuring equipment (UCS SID - Shoe Inner Dimension) is more complex and has been designed for massive scanning of large quantities of shoes in a short time (http://www.ucstech.eu/otherproductsservices/shoeinnerdimension.html). Details of the process may currently not be revealed due to commercial reasons. The resulting 3D geometry of a sample shoe model is depicted on Fig. 2.

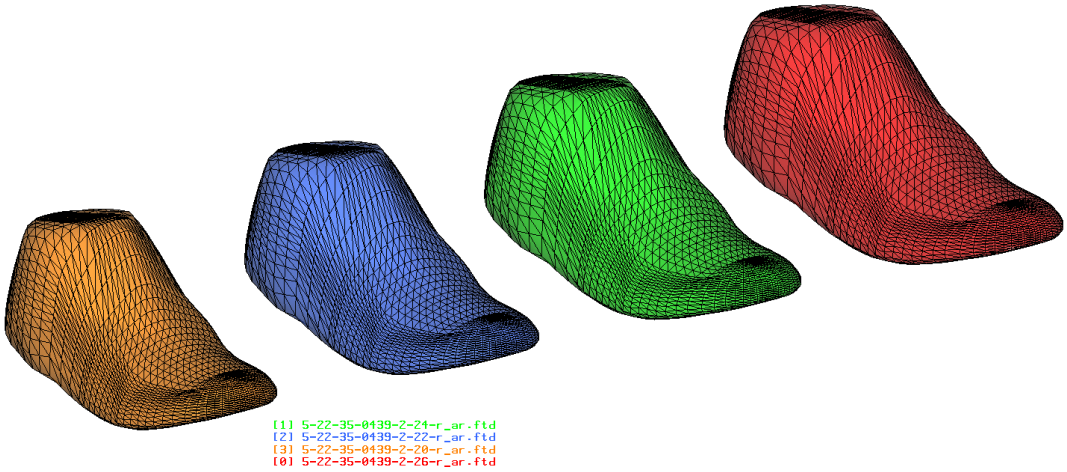

Fig 2: 3D shoe models of subsequent sizes of the same shoe model

The CSSRS-Child Shoe Size Recommendation System consists of the following components: database of 3D feet models, database of measured shoes containing 3D models and other data, foot growth prediction system, matching algorithm and a graphical user interface (GUI) with comprehensive presentation of relevant data (see Fig. 3). The most convincing feature of the system turned out to be the graphical presentation of simultaneous overlaying of top view silhouettes of child's foot and the compared shoe, which clearly indicated the available space in the front part of the shoe. The GUI also enabled expected temporal growth of the foot geometry, and therefore it was easier to understand the predicted expiration time.

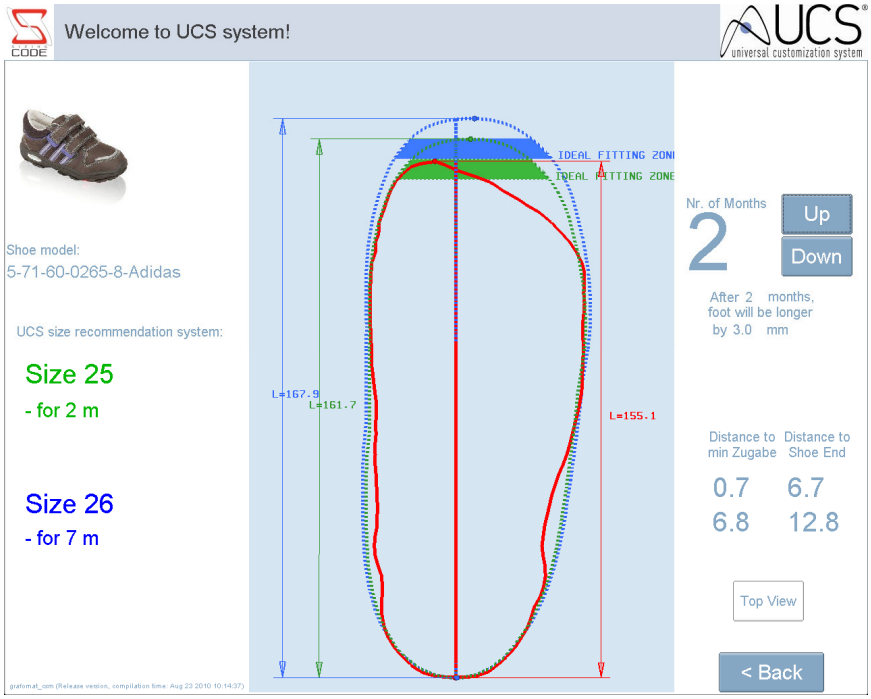

Fig. 3: Part of CSSRS graphical user interface

In our research, 89 children (44 % male, 56% female) in age range 2 to 7 and their parents were invited to company headquarters for fitting tests. They were asked to bring several shoes that are currently worn by their children. Altogether 172 of worn shoes (each shoe model in a single size) were

brought to measurement. UCS also provided additional test shoe models (brand new ones), which were available in complete child size ranges (EU 19 to 33).
The test procedure was as follows:

A) brought shoes were measured on SID,
B) parents gave an estimation, how long their child can still wear the shoes, before they will be too small ("expiration time", in months),
C) children's feet were scanned with both scanners,
D) children tried brand new shoe models, where parents were asked to select the most appropriate sizes and give an estimation of expiration time,
E) parents were presented by the CSSRS,
F) parents were asked again to estimate the expiration times for all the shoes.

The answers were collected in a poll and entered into a database for later analysis.

3. Results

Several analyses on the collected data were performed with different aims. In this paper, we present the results on the following question:

How many parents are able to select the "correct" size of shoes for their children?

We were interested, weather the CSSRS provided additional information, which influenced their estimations. We therefore compared their estimations of expiration times (ET) before using the CSSRS and after using it. Graph on Fig. 4 depicts the difference *ET_before* minus *ET_after*. If the difference is positive, the parents initially overestimated the ET.

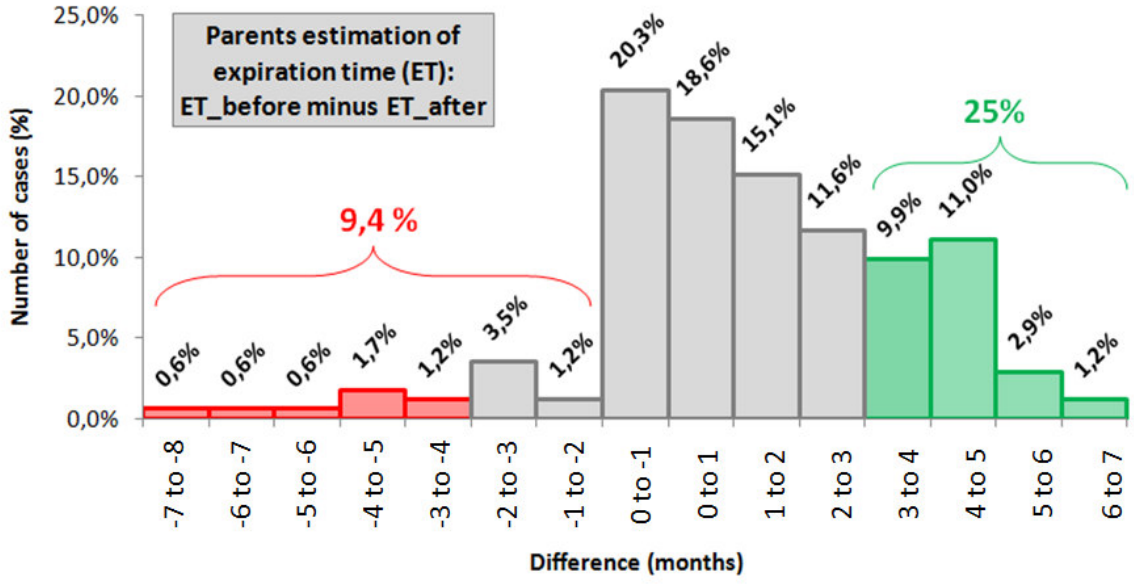

Fig. 4: The difference in parents' estimation (ET_before minus ET_after)

We may observe the following features:

a) The majority of parents (91%) initially overestimated the ET,
b) 25% of parents overestimated ET for more than 3 months, which may be interpreted as "more than one season".

Parents generally had difficulties to give an exact estimation of the ET in months (who can exactly tell whether the shoe expiration time is 3 or 4 months?). We therefore asked parents to additionally give a more simple estimation: "this shoe is currently too small" or "this shoe is currently big enough", which brings us to the next question:

How did the CSSRS system influence parents' estimations?

In 83 of 172 valid cases (48,3%) parents claimed that shoes were "to small" after using CSSRS. Only 14 of them (8,1%) claimed to be "to small" before using CSSRS. Other 69 (40,1%) changed their mind from "big enough" to "too small" (see Fig. 5).

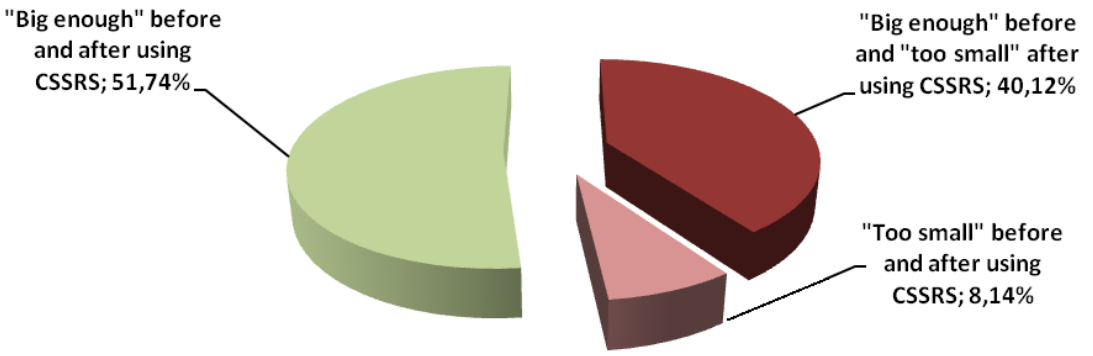

Fig. 5: Comparison of parents' estimation before using CSSRS and after using it

Fig. 6 depicts the distribution of ET estimations before using the system for all 83 cases (48,3%), where parents claimed "too small" after using CSSRS.

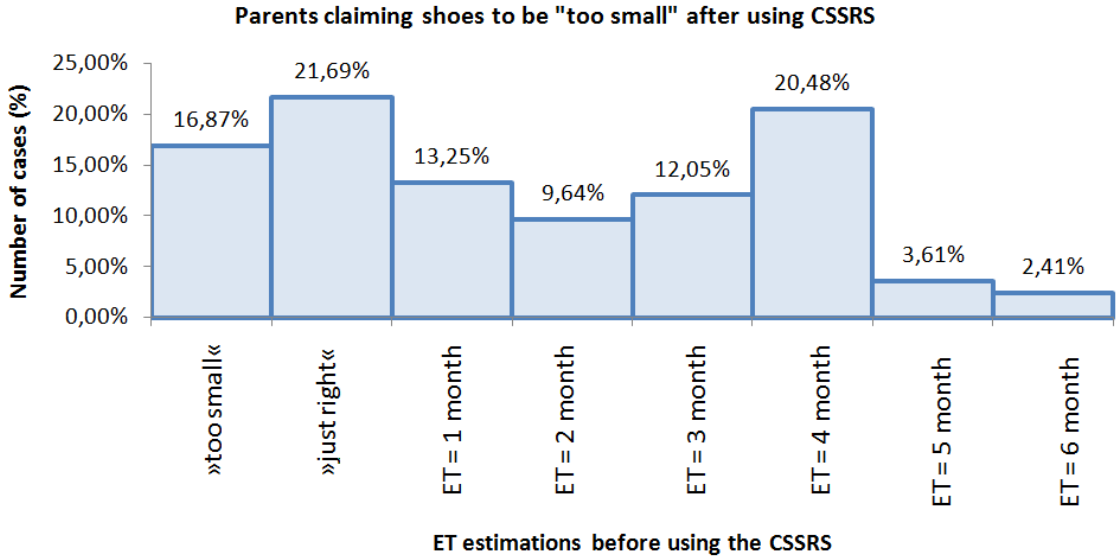

Fig. 6: Distribution of ET estimations before using the CSSRS

We performed another analysis to show, how consistently parents can estimate the shoe size. We selected only parents, whose estimations before were "big enough" and after "too small". Among them there were 40 cases, where parents brought more than a single pair of shoes with them. Fig. 7 shows, which parents (although wrong) were very consistent (cases 11, 12, 80, 90, 91), and which ones estimated their shoes very differently with respect to their final decision (cases 32, 50, 63).

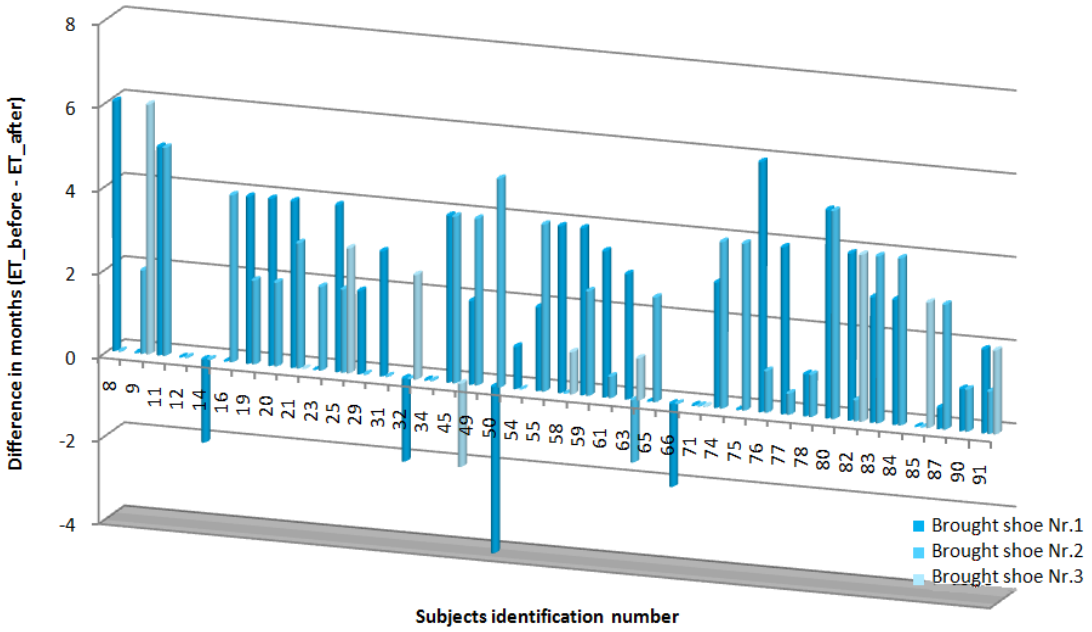

Fig. 7: Comparison of difference in estimation before/after at specific cases

4. Conclusions

Majority of parents overestimated the “expiration date” of shoes they brought with them, one quarter for more than 3 months (which equals one season). The basic problem is a lack of understanding of the importance of free space in the front part of the shoe needed for growth and movement during activities. Only about 8% of parents knew that their children wear shoes that are already too small. The result is of a big concern, since children’s feet grow rapidly and improper footwear can affect their health. Parents have shown a lot of understanding for this issue and are interested in providing their children with perfect fit footwear, but they lack a proper tools or methods for selecting shoes. They rely mostly on the length of the foot (which also is not detected correctly) while neglecting other possible pressure points in the front part of the foot.

This study showed that many parents doubt their shoe size estimations and can quickly change their mind, when provided by consistent and trustful information. CSSRS system provides parents with better perception about the feet and shoes dimensions so they can choose more accurately. 40% of parents changed their initial estimation from “big enough” to “too small” after using the CSSRS. Feet and shoes are measured precisely, compared and presented trough graphical user interface, where parents receive better information about the free space in toe area. Most importantly, they receive information about the expected growth of child’s feet according to his age, so they can choose shoes for certain period of time. Using 3D measurement technology helps parents to choose shoes of better fit and reduce the possible discomfort, pain, deformation and other foot problems.

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