Kidsize: Always Get the Right Size!

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Abstract

This paper describes the two innovations underpinning Kidsize concept and presents the results of their validation. The first one is a mobile phone app to measure a child in 3D by taking two pictures. This new method is more accurate and consistent than an untrained person using a measuring tape at home or in the shop. The second one is an expert system that recommends the size that best fits the child and assesses the fit of the garment at different body areas. Project results show that it can provide nearly 90% right size recommendations, thus outperforming existing methods like age- or height-based size guides, which achieve 40 and 60% right recommendations respectively.

Keywords: 3D scanning, anthropometry, body models, avatar, mannequin, children, childrenswear, size, apparel, garment, clothing, fit, online, measurement, shape, data-driven, phone, tablet, app.

1. Introduction

Getting the right size without trying the clothes on is a challenge [1] that every parent faces whenever they intend to buy clothing for their children, either online or at brick-and-mortar stores. Children's sizing has the particularity of being designed based on statures but being labelled according to age (i.e. months and years); even though children of the same age may have different dimensions and body proportions. Moreover, parents do not always take their children with them to the shops and when they do, they rarely try the garments on them. The problem becomes even more acute if it is a friend or relative who wants to make a gift. These facts, together with the differences in the growing pace of children, create confusion among buyers when they have to pick a size for a child.

In this context, Kidsize project [2,3] aimed at developing technologies to help childrenswear manufacturers and retailers to sell more, by clearing up the size-related concerns when buying online or at the retail stores when parents buy without their children, and to sell better, by cutting down the expenses derived from product returns both at online and retail stores.

In particular, Kidsize targeted at providing parents (or relatives) with the information required to pick the right size for their children. In the Kidsize concept, this information included:

a) a size recommendation for wearing the garment straight away (herein "expert's advice")
b) a size recommendation for the best fit to allow room for the child to grow (herein "parents' advice")
c) how the garment is expected to fit the child at relevant body areas like the shoulder, the chest, the hips, the sleeve length or the trouser length (herein "fit-by-area")

In order to provide this information, it is necessary to establish rules/models that explain/simulate the user-product interaction [4,5,6,7,8], which in our childrenswear context means "wearing the garment comfortably with an aesthetically nice fit". If such rules, models and/or simulations are expected to be somehow reliable, it is necessary that they are based on reliable information/properties from the person (e.g. body dimensions, shape or preference) and from the garment (e.g. dimensions, style, type of garment or materials).

Reliable information/properties of the garment can be available to the producers or merchants that have access to the product (or to its design) along the supply chain. Any producer or brand which has a narrow control of the conception and/or of the quality control of their products should have access to it.

In contrast, a regular person does not have access to reliable dimensional information of him/herself or of his/her children (except for, maybe, body height and weight). The two methods for reliably and consistently measuring the human body are: being measured by an expert [9,10] or being 3D-scanned. Unfortunately, nowadays none of these methods are readily available when we buy online at home or when we go shopping to brick-and-mortar stores.

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Within this context, the R&D work conducted under Kidsize project (figure 1) was focused on three scientific and technical challenges:

1) Developing a reliable body measuring instrument that could be used almost anywhere, at any time and by anyone (i.e. that does not require any special expertise).
2) Developing algorithms that could provide a right size advice in most of the cases, i.e. 90%.
3) Implementing a prototype solution adapted to the needs of the stakeholders involved in the purchase of childrenswear, i.e. the buyers, the manufacturers and the retailers.

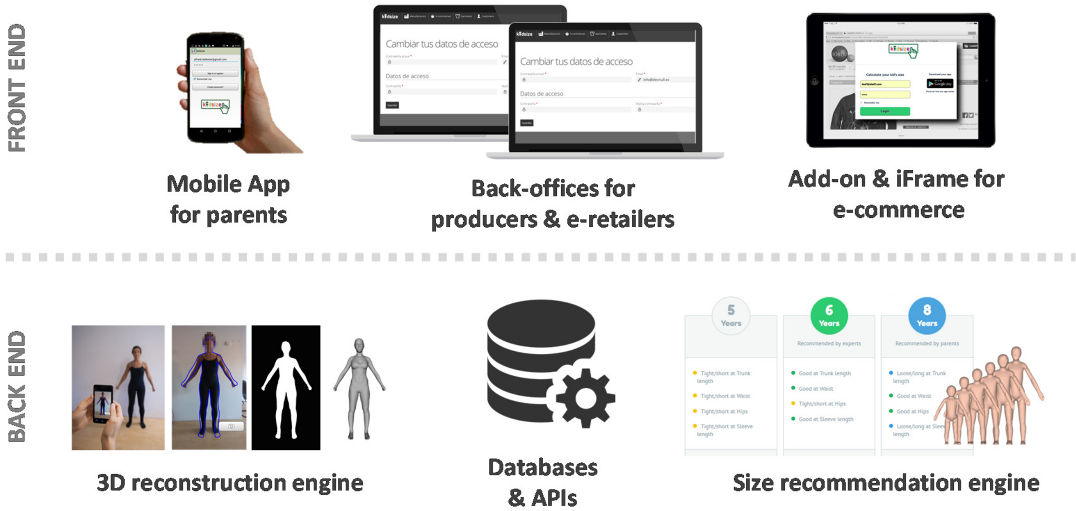

Figure 1: Kidsize concept incl. the main back-end and front-end components

This paper focuses on the first two objectives. Section 2 of this paper describes the body measuring instrument and the size recommendation technology. Section 3 describes the validation studies conducted within the project and their results and Section 4 summarises the conclusions drawn.

2. Description of the technologies

2.1. Kidsize app – a new body measuring instrument

The access to the 3D representation of people's body would be the best source of shape and dimensional information about the body. However, there are several barriers that have hindered the massive spread of 3D scanners as consumer goods or as a typical in-store appliance: the price is high and devices are too bulky for homes and retail stores; and many of them require expertise to achieve a quality scan and to locate the anatomical references to get the right measurements.

In Kidsize we developed an approach for estimating the 3D shape of a child's body just by taking him/her a couple of pictures using a smartphone application (figure 2). That way, the body measuring instrument could be available at any place with internet access.

Figure 2: Kidsize app for phones and tablets

Our approach is based on data-driven methods for 3D reconstruction [11,12]. For children that cannot stand or follow instructions (until 3 years-old) our method uses a Partial Least Square (PLS) regression to obtain 19 body dimensions from age, gender, height and weight reported by parents. The regression model was built from a database of 276 children aged 0-3 y.o. measured by an expert using traditional methods.

For children from 3 years-old, our approach is based on segmenting the body outlines from two images and then optimising a parameterised body shape model until the outlines of its projections match the segmented outlines from the images [13]. The children's body shape model was obtained by applying Principal Components Analysis (PCA) [14,15] to a database of 761 registered 3D scans of children aged 3-12 y.o. [16]. The two photographs (front and side) are taken with the child standing, wearing tight clothing (or swimwear) in front of a clear wall. In order to facilitate this process, the app provides a guiding silhouette. For segmenting the body figure from the background we used an adaptation of Grabcut algorithm [17]. The body height of the child reported by the parents and the camera parameters of the phone/tablet are used to calibrate the images. The 3D reconstruction optimization is computed on the cloud but the segmentation of the images is made in the phone so that actual children images are not sent through the Internet. The app was implemented for Android 4.4+ phones/tablets.

2.2. Kidsize algorithms for giving size advice and estimating the garment fit

Kidsize provides size advice (expert's and parents') and fit predictions from a set of body measurements of the child and the properties of the garment (figure 3). In order to model and explain the child-garment interaction we used Ordinal Logistic Regression (OLR) with stepwise variable selection and a set of expert rules using an adaptation of the methods proposed by Alemany et al. [1].

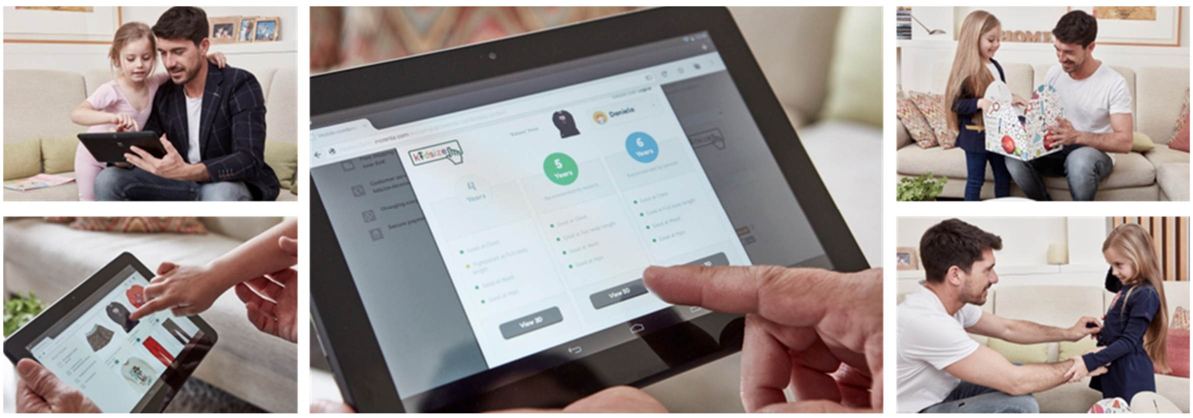

Figure 3: Kidsize's size advice and fitting prediction

The OLR models were trained using experimental data from over 1100 garment evaluations (fit trials). 11 garments of different types (incl. bodysuits, rompers, trousers, t-shirts, shirts, skirts and dresses) where provided in all their size spans by two childrenswear brands (i.e. Lullaby and Bóboli). 160 children aged 0-12 y.o. and their parents voluntarily participated in the fit trials (figure 4). Prior to the fit trials the participants were measured using traditional methods (0-3 y.o.) or using Vitus XXL 3D body scanner (3-12 y.o.). 19 and 36 body dimensions were measured respectively for babies and children.

Figure 4: Images of the fit trials

At each fit trial session, the child tried on at least two garments in at least two sizes. At each fit trial, the size was evaluated by a fashion expert using a three-level scale (small, correct or big) and by parents who declared if they would pick the size or not. Moreover, the expert also assessed the fit at the relevant body areas using a five-level Likert scale ranging from very tight/short to very loose/long. The relevant body areas defined were different depending on the type of garment (figure 5).

Figure 5: examples of the relevant body areas for a dress and a shirt

A total of 12 different OLR models (equation 1) were defined according to: the type of advice (expert and parents), the age market segment (babies 0-3 y.o. and children 3-12 y.o.) and the type of garment (upper body, lower body and full body). Two models (one for babies and one for children) were also defined for each of the 19 body fit areas (38 fit-by-area models in total). The original measurement sets were reduced to 9 variables by the stepwise variable selection (figure 6).

$$logit\big(P(fit \leq A|X_1, \dots, X_k)\big) = \ln\left(\frac{P(fit \leq A|X_1, \dots, X_k)}{1 - P(fit \leq A|X_1, \dots, X_k)}\right) = \theta_{A\,|\,A+1} - (\beta_1 X_1 + \cdots + \beta_k X_k),$$

$$A \in \{small, good, large : small \leq good \leq large\}$$

$$\begin{aligned} P(fit = small \mid X_1, \dots, X_k) &= e^{[\theta_{small\ \mid good} - (\beta_1 X_1 + \cdots + \beta_k X_k)]} \\ P(fit = good \mid X_1, \dots, X_k) &= e^{[\theta_{good\ \mid large} - (\beta_1 X_1 + \cdots + \beta_k X_k)]} - P(fit = small \mid X_1, \dots, X_k) \\ P(fit = large \mid X_1, \dots, X_k) &= 1 - P(fit = small \mid X_1, \dots, X_k) - P(fit = good \mid X_1, \dots, X_k) \end{aligned}$$

Equation 1: General formula and probability formulae for size advice prediction

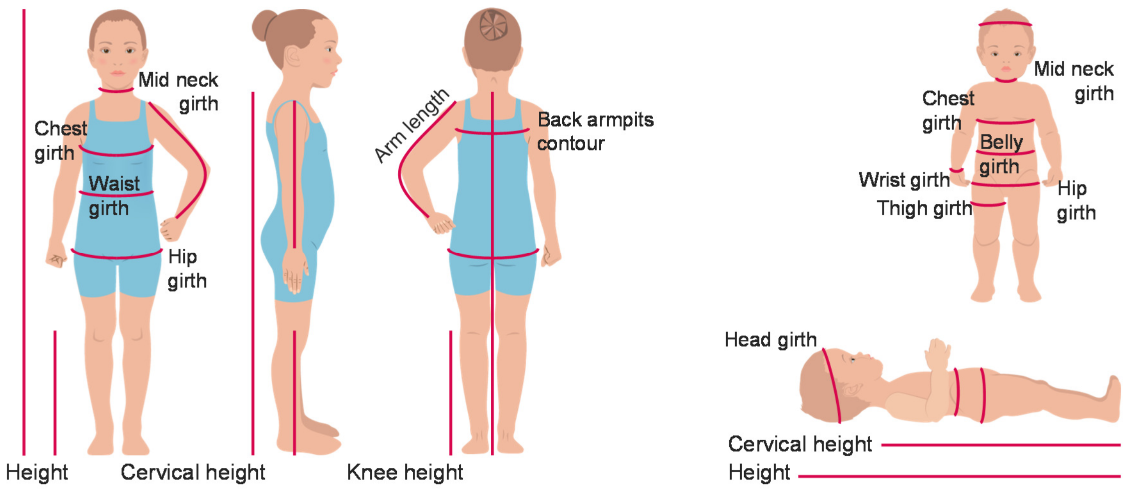

Figure 6: set of 9 body measurements selected for children and babies' OLR models

The expert rules that applied to the output probabilities of the models were very simple:

- The recommended size was the biggest size with good fit.
- If all sizes were big or all sizes were small, the system would not recommend any size.
- If the child was between two sizes (there is no size with a clear good fit), the recommended size was the bigger of the two.
- The parents' advice was always equal or one size bigger than the experts'.

3. Validation studies and results obtained

3.1. Precision of Kidsize app (repeated measurements)

In order to assess and quantify the precision and consistency of the body measurements obtained using Kidsize app, we conducted a study using scale figurines. Six synthetic children shapes representing the boundaries of the body shape space were generated and manufactured in 1:10 scale using a Solid Laser Sintering (SLS) machine from EOS (figure 7). Each of the figurines was photographed 10 times in a contrast controlled environment. Its actual height was used as scale up parameter for the 3D reconstruction.

Figure 7: virtual models, scale figurine set, controlled background and picture taking process

The body measurements obtained from the app were compared to the actual measurements of the virtual models. To evaluate the error in measurement estimation, the Mean Absolute Difference (MAD) for repeated measurements was computed (equation 2), where n is the number of figurines and r_i is the number of repetitions for figurine i, in this study (10 repetitions), $r_i = 10$ for all i.

$$MAD = \frac{1}{n}\sum_{i} \frac{1}{\binom{r_i}{2}} \sum_{s=1}^{r_i-1} \sum_{t=s+1}^{r_i} \left| m_s^i - m_t^i \right|$$

Equation 2: Mean Absolute Difference (MAD) for repeated measurements

Table 1 gathers the results obtained for the measurements used in size advice and compares it to the results obtained by different studies of precision of high resolution 3D body scanners in adults.

Table 1: Precision (MAD in mm and %) of Kidsize app with scale figurines compared to 3D scanner precision results from bibliography (Lu & Wang, 2010; Dekker, 2000; Robinette & Daanen, 2006)

Measurement name	Kidsize MAD	Kidsize MAD %	3D scanner MAD*	3D scanner MAD [18]	3D scanner MAD [19]	3D scanner MAD [20]
Knee height	3	1%	3	1	4	
Mid neck girth	5	2%	3			
Chest girth	8	1%	10	2	6	
Back armpits contour	6	2%	8	1		
Seat girth	6	1%	4		2	
Cervical height	3	0%	3		4	
Waist girth	8	1%	5	3	3	
Arm length	6	1%	5	5		5

3.2. Accuracy of Kidsize app in babies (compared to expert measurements)

In order to determine the accuracy of Kidsize App for babies compared to traditional anthropometric methods, we conducted a study with 30 children aged 0-3 y.o. Each child was measured using both methods. An anthropometry technician (expert) measured the babies for 19 measurements plus body mass and body length. A parent (non-expert) measured body mass and length and used them to get the 19 measurements with the app.

* Results obtained by IBV in non-published results of repeatability tests (4 repetitions) with children using Vitus XXL 3D body scanner and own developed tools for posture harmonisation and digital body measuring [15].

Firstly, we analysed the differences between parents' and expert's input, i.e. body mass and body length, using a paired t-test of the mean difference. Test results showed that there were no significant differences ($p<0.05$) between weight and height measured by parents or experts. The differences of the averages observed were of -0.2 Kg for body mass and of -0.2 cm for body height. Secondly, we calculated the Mean Absolute Difference (MAD) to have an estimate of accuracy for the predicted measurements (equation 3), where n is the number of babies.

$$MAD = \frac{1}{n}\sum_{i}\left|m^{i}_{Kidsize} - m^{i}_{reference}\right|$$

Equation 3: Mean Absolute Difference (MAD)

Table 2 summarises the results obtained for the measurements that are used in the size advice for babies and it is compared to bibliographic results of measurements taken by non-experts.

*Table 2: Accuracy (MAD in mm and %) of Kidsize app for babies (Kidsize vs. expert) and its comparison to the accuracy of measurements taken by non-experts (non-expert vs. expert) from bibliography (*Yoon & Radwin, 1994*)*

Measurement name	Kidsize MAD	Kidsize MAD %	Non-expert MAD [10]
Mid neck girth	14	6%	22
Chest girth	12	3%	24
Cervical height	14	2%	35
Waist girth	15	3%	35
Head girth	12	3%	-
Hip girth	18	4%	53
Belly girth	15	3%	24
Wrist girth	8	7%	24
Thigh girth	13	5%	35

3.3. Accuracy of Kidsize app in children (compared to high resolution 3D scanners)

In order to determine the accuracy of Kidsize App for children compared to 3D body scanners, we conducted a study with 34 children aged 3-12 y.o. Each child was scanned with Vitus XXL 3D scanner and measured using our data-driven 3D reconstruction app. To evaluate the error in measurement estimation using the app compared to body scanner, the Mean Absolute Difference (MAD) for repeated measurements was calculated (equation 3), where n is the number of children.

Table 3 summarises the results obtained for the measurements that are used in the size advice for children and it is compared to bibliographic results of the accuracy of measurements taken by non-experts.

*Table 3: Accuracy (MAD in mm and %) of Kidsize app for children (Kidsize vs. 3D scan) and its comparison to the accuracy of measurements taken by non-experts (non-expert vs. expert) from bibliography (*Yoon & Radwin, 1994*)*

Measurement name	Kidsize MAD	Kidsize MAD %	Non-expert MAD [10]
Knee height	10	3%	41
Mid neck girth	11	4%	22
Chest girth	21	3%	24
Back armpits contour	20	7%	15
Seat girth	12	2%	53
Cervical height	11	1%	35
Waist girth	18	3%	35
Arm length	13	3%	24

3.4. Reliability of the size advices provided by Kidsize

In order to assess the reliability of the size advices provided by Kidsize Solution, we made a test involving a group of volunteers meeting the target customer profile: parents with one or more children that sometimes buy childrenswear online. 30 children (23 parents) participated in the test. They were selected to have a gender- and age-balanced sample (10 children aged 0-2 years old, 10 children aged 3-7, and 10 children aged 8-12).

The childrenswear brands participating in the project (Bóboli and Sucre d'Orge) provided 19 different garments (figure 8) in all the available sizes for the testing. The two brands activated the products in Kidsize system by entering garment properties using the prototype back-office for brands.

Figure 8: sample of garments used in the test (incl. babies', boys' and girls' garments)

The tests took place at two locations: at a Bóboli shop located in a mall (C.C. Bonaire) in Valencia (figure 9) and at a simulated multi-brand shop at IBV facilities. We prepared a fully working online demo shop including the Kidsize add-on button in the product selection page so that the participants could use it on a tablet during the tests (figure 9). Temporarily, Kidsize app was uploaded to Google Play in order to facilitate its distribution to the testers (figure 9).

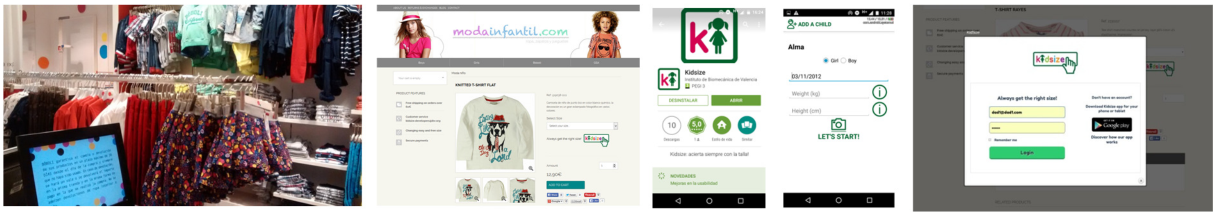

Figure 9: Bóboli shop, online demo shop, Android app and iFrame at online shop

During the test, each participant was asked to use the Kidsize app to measure his/her child and to go shopping four garments at the online demo shop. The four selected garments were randomly assigned to each participant according to a balanced design of experiments. For each of the garments evaluated, the parents tested first the size (or sizes) advised by Kidsize (expert's and parents) and were encouraged to test other sizes. Then, the parents were requested to pick one size for wearing the garment straight way and to pick the size that they would buy (usually letting room for the child to grow); they were allowed to select the same size in both cases. At the end of the test, they were also requested to answer some questions about their experience using Kidsize.

The reliability of the size advice provided by Kidsize was compared with the available alternatives, i.e. a size guide based on children stature provided by the brands, and the labelling of garment sizes, which uses the ages as reference. Results are presented in Table 4.

Table 4. Reliability of size advices provided by Kidsize compared to state of the art solutions

	Size Guide (stature)	Garment label (age)	Kidsize
Expert's advice	54%	42%	85%
Parent's advice	59%	48%	88%

Regarding the subjective evaluation, Kidsize solution was positively assessed by parents, who found it very promising for resolving their concerns when buying without trying on the garments. In general, it was considered very useful, reliable and easy-to-use. Some of the respondents requested a similar tool for adults.

4. Discussion and conclusions

Most of the size recommendation systems available in the market use body measurements reported by the users. However, body measurements, apart from body height and weight, taken by a non-expert using a measuring tape are not reliable providing an accuracy of 2-5 cm [10]. 3D scanners are much more reliable instruments for this purpose [18,19,20], but they are not available at most homes or shops.

According to our results, Kidsize app can provide an accuracy of 1-2 cm and a precision of <1cm. This makes our new method more accurate than an untrained person using a measuring tape and almost as consistent as a 3D body scanner. These values seem adequate for performing size recommendations because they lay within half of the size step for most of the body dimensions. Moreover, a mobile application can be used to measure a child at home or at any shop.
Most of the returns of childrenswear are reported to be due to wrong sizes. This problem affects both the online and the brick-and-mortar channels because parents or relatives do not bring the children to the shops, and when they do they do not try on the garments. According to our results, the size guides that are available at the points of sale of childrenswear fail to give a right advice in nearly half of the cases (48-59% right recommendations).

According to our results, Kidsize was consistent with parents' opinion for 85-88% of the size recommendations made, clearly outperforming the size guides.

The reliability of the size advices provided by Kidsize showed a similar performance than previous studies conducted with adult female garments (86-93%) using also OLR for modelling the user-garment try-on interaction [1]. The performance results obtained by unidimensional size guides (stature- or age-based) in this study (48-59%) are also similar to those obtained by tri-dimensional size guides (bust-waist-hip) used in the female study (41-64%).

The differences between the performance of OLR-based methods and the size guides could be explained by two reasons. Firstly, because the product properties used in the children and female studies were actually measured or verified, while the size guides published by brands may not correspond to actual product properties. Secondly, it is possible that more than 2-3 measurements are required to model the try-on of garments and provide a reliable size advice. The number of variables used in existing size guides (and in many size recommendation systems available in the market) ranges from 1 to 3, while the number of body dimensions used in Kidsize ranged from 5 to 9 and in the female study they ranged from 6 to 20.

Kidsize innovations showed to be very promising but several improvements should be made before shifting from prototypes to products. Further work will include extending the 3D body reconstruction to adults and developing size recommendation and fit-by-area algorithms for adult garments. Moreover, the forthcoming availability of depth sensors in mobile phones and tablets [21,22] will bring an opportunity to refine and improve data-driven 3D reconstruction technologies.

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References

[1] Alemany, S.; Ballester; A., Parrilla; E., Uriel, J.; González, J.; Nácher, B.; González, J.C.; Page, "A. Exploitation of 3D body databases to improve size selection on the apparel industry", in *Proc. of 4th Int. Conf. on 3D Body Scanning Technologies*, Long Beach, CA, USA, November 2013.

[2] "Development of a new extended product-service to overcome size assignment and fitting barriers for children fashion on-line market addressing customer needs" (KidSize), *FP7, European Commission*, FP7-SME-2013-606091, 2014-2016, www.kidsizesolution.com

[3] Kidsize at YouTube, www.youtube.com/channel/UC9Myhl722CSGlSIWKER3H0g (29/09/2016)

[4] HFES 300 Committee, ed. *Guidelines for using anthropometric data in product design*, Human Factors and Ergonomics Society, 2004

[5] Loker, S., Ashdown, S. and Schoenfelder, K., "Size-specific analysis of body scan data to improve apparel fit", *Journal of Textile and Apparel, Technology and Management* 4.3 (2005): 1-15

[6] Robinette, K. M., "Anthropometry for product design." *Handbook of Human Factors and Ergonomics 4*, 2012, pp 330-346.

[7] Robinette, K. M., and Veitch, D., "Sustainable Sizing", *Human Factors: The Journal of the Human Factors and Ergonomics Society,* 2016, 0018720816649091

[8] Gill, S., "A review of research and innovation in garment sizing, prototyping and fitting", Textile Progress, 47:1, 1-85, 2015, DOI: 10.1080/00405167.2015.1023512

[9] Gordon, C. C., Bradtmiller, B., Churchill, T., Clauser, C. E., McConville, J. T., Tebbetts, I. O., and Walker, R. A., "1988 Anthropometric Survey of US Army Personnel: Methods and Summary Statistics", *Natick, MA, US Army Natick Research Development and Engineering Center*, 1989.

[10] Yoon, J.C., and Robert G. R. "The accuracy of consumer-made body measurements for women's mail-order clothing". *Human Factors: The Journal of the Human Factors and Ergonomics Society*, Vol. 3, No. 3, pp. 557-568, 1994.

[11] Parrilla, E.; Ballester, A.; Solves-Camallonga, C.; Nácher, B.; Puigcerver, S.A.; Uriel, J.; Piérola, A.; González, J.C.; Alemany, S., "Low-cost 3D foot scanner using a mobile app", *Footwear Science*, Vol. 7, Iss. sup1, 2015.

[12] Ballester, A., Parrilla, E., Vivas, J. A., Piérola, A., Uriel, J., Puigcerver, S. A., Piqueras, P., Solves-Camallonga, C., Rodríguez, M., González, J. C., and Alemany S, "Low-Cost Data-Driven 3D Reconstruction and its Applications", In Proc. of *6th Int. Conf. on 3D Body Scanning Technologies*, Lugano, Switzerland, October 2015. doi:10.15221/15.184

[13] Parrilla, E., Ballester, A., Uriel, J., Piérola, A., Pérez, C., Piqueras, P., Nácher, B., Vivas, J. A. and Alemany, S., "Data-driven 3D reconstruction of human bodies using a mobile phone app" , *Int. J. of the Digital Human*, Special *Issue on 3D Anthropometric Databases and Their Applications* (submitted 30/06/2016, under review).

[14] Allen, B., Curless, B., and Popović, Z., "The space of human body shapes: reconstruction and parameterization from range scans", *in ACM ToG*, Vol. 22, No. 3, pp. 587-594, 2003.

[15] Ballester, A., Parrilla, E., Uriel, J., Piérola, A., Alemany, S., Nacher, B., González, J. and González J.C., "3D-Based Resources Fostering the Analysis, Use, and Exploitation of Available Body Anthropometric Data", *in Proc. of 5th Int.Conf. on 3D Body Scanning Technologies*, Lugano, Switzerland, October 2014. doi:10.15221/14.237

[16] Ballester, A., Valero, M., Nácher, B., Piérola, A., Piqueras, P., Sancho, M., Gargallo, G., González, J. C., and Alemany S., "3D Body Databases of the Spanish Population and its Application to the Apparel Industry", In Proc. of *6th Int. Conf. on 3D Body Scanning Technologies*, Lugano, Switzerland, October 2015. doi:10.15221/15.232

[17] Rother, C., Kolmogorov, V., and Blake, A., "Grabcut: Interactive foreground extraction using iterated graph cuts", In *ACM Transactions on Graphics*, Vol. 23, No. 3, pp. 309-314, 2004

[18] Lu, J. M., and Wang, M. J. J., "The evaluation of scan-derived anthropometric measurements" Instrumentation and Measurement, IEEE Transactions on, 59(8), 2048-2054, 2010.

[19] Dekker, L. D., "3D human body modelling from range data", PhD thesis, Doctoral dissertation, University of London, London, United Kingdom, 2000.

[20] Robinette, K. M., & Daanen, H. A., "Precision of the CAESAR scan-extracted measurements", *Applied Ergonomics*, Vol. 37, No. 3, pp. 259-265, 2006.

[21] Structure for iPad, http://structure.io/ (29/09/2016)

[22] Project Tango from Google, https://developers.google.com/tango/ (29/09/2016)

[23] DPI2013-47279-C2-2-R. "Herramientas para la predicción de la talla y el ajuste de ropa infantil a partir de la reconstrucción 3D del cuerpo y de técnicas 'big data'" (TALLA-ME) Programa Estatal de Investigación, Desarrollo e Innovación Orientada a los Retos de la Sociedad.