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# Evaluation of Depth Cameras for Use as an Augmented Reality Emergency Ruler

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**Abstract.** Children are rarely affected by medical emergencies. The experience of doctors or paramedics with child emergencies is correspondingly poor. The anatomical features and individual calculations make such an emergency much more error-prone than a comparable adult emergency. Particularly in dose calculations, critical errors occur time and again. Since these calculations are based on the child's weight, which is preclinically often derived from the size of the child, the number of errors can be minimized with an assistance service that performs all calculations based on the size. Technically, it is possible to detect the size with a depth camera, which is occasionally installed in smartphones or head-mounted displays. In order to investigate to what extent these cameras provide precise results, a study with 33 children was carried out. The children were measured with both an emergency ruler and an augmented reality app with associated smartphone with depth camera. The result is that the depth camera does not provide significantly different results than an emergency ruler. This allows further research, e.g. the automatic recognition of patients with the help of machine learning or usability studies, to be tackled.

**Keywords.** child, emergencies, resuscitation, mobile applications, user-computer interface

## 1. Introduction

Medical emergencies involving children are rare occurrences. In Germany, experts estimate that about 4000 children are resuscitated every year, 1000 of them preclinically. On the other hand, there are about 30,000 doctors with the additional designation "emergency medicine". An emergency physician would thus mathematically reanimate a child every 30 years [1]. The resulting lack of routine, combined with anatomical features in children, individual dose calculation and time-critical procedures, make pediatric emergencies error-prone. In a survey of 104 emergency physicians conducted by Zink et al., 88% of those questioned stated that they had already felt a sense of anxiety or personal overexertion during work. In response to the question in which situation this feeling arose, 84% of the physicians answered that they had had this feeling in a pediatric emergency, followed by polytraumatized patients (20%) and obstetric emergencies (18%). Multiple responses were possible [2]. Due to the lack of routine, it is essential to have the emergency guidelines [3] issued regularly by the European Resuscitation Council (ERC) at hand. The process as well as the activities themselves differ significantly in children and adults. According to the current guidelines, children are

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resuscitated, for example, after five initial ventilations in a 15:2 rhythm (thoracic compression to ventilation), while adults start in a 30:2 rhythm. Intubation is also more difficult due to the anatomical characteristics [4]. However, the most frequent errors occur in the dosage of medication. Children are particularly susceptible here because the dose must be calculated or estimated individually, depending on their weight. As Young and Korotzer have pointed out in their systematic analysis, parental estimation is the most accurate method for determining weight, followed by the size-based method where weight is derived from the child's height using survey data (e.g. German Health Interview and Examination Survey for Children and Adolescents (KiGGS) [5]). Medical doctors' weight estimates are not accurate [6]. But even if the weight is known, calculation errors occur due to nervousness or hecticness. As part of a study by Hoyle et al., 125 out of 360 prescriptions were made with dosage errors. Especially in preclinical environments these errors happen frequently. The reason for this is probably the lack of experience of emergency paramedics or emergency physicians with pediatric emergencies [7]. In a further study with simulated resuscitation, incorrect doses of a potency of 10 (1000% of the recommended dose) took place with one of 32 prescriptions - these can pose a life-threatening risk [8]. Young, inexperienced physicians, who make up the majority of emergency physicians, are particularly susceptible [9]. Based on these facts, physicians want electronic tools, such as a computer program or a calculator, because they can demonstrably minimize calculation errors [8][10]. Such a computer program could directly perform all necessary calculations, be it the dosage of drugs or the current strength of the defibrillator. But the weight or height still has to be known first. Even better, of course, would be the automatic recognition of the weight or size. This means that calculation errors can be ruled out if the detection is error-free. At the moment, so-called emergency rulers (e.g. Browselow Tape [11] or PediaTape [12]) are the most important aids alongside the guidelines. An emergency ruler is placed next to the head of a child. A color code can then be read off at the feet, which can be used to indicate dosage recommendations or age-appropriate reactions, e.g. to the Glasgow Coma Scale. This information is often stored in a brochure supplied with the ruler (Figure 1). The dosage recommendations may also be printed directly on the tape.


**Figure 1.** PediaTape with corresponding booklet [12].

Technically, size recognition is possible with the help of depth cameras, some of which are built into smartphones (Asus Zenfone AR, Lenovo Phab2 Pro) or head-mounted displays (Microsoft HoloLens). These cameras are designed for augmented reality (AR) applications. They are necessary for the most error-free placement of AR elements in a room. These cameras can be programmed with the Tango Framework from Google [13] among others. With the help of the depth camera and Google Tango Framework it is possible to perform accurate measurements. The depth camera scans the room and gets to know the environment of the user. Thus, it is possible to carry out the measurements within one to two seconds from any point and at any angle near the object to be measured. But the question is, how accurate are these cameras in reality? Only exact cameras are suitable for this type of application. This paper presents a study in which 33 children aged between 3 and 6 years were measured with an emergency ruler and an augmented reality app on a smartphone with a depth camera. The results were then compared. The aim was to find out to what extent the size measurement functions solidly and thus further work in this research area is meaningful.

## 2. Methods

First a systematic PubMed and Google Scholar search according to the PRISMA scheme was indicated to investigate if there are already similar works or important preliminary works.

Subsequently, a study design was developed that allows to compare an augmented reality app on a standard smartphone with depth camera (Asus Zenfone AR) with an emergency ruler (PediaTape). For this purpose, an augmented reality app was written, which uses Libraries of the Google Measure App [14], an already existing app for measuring lengths. Using the Google Measure App (tango version) directly was unfortunately not possible because it often rounds off the results.

Afterwards 33 children aged between 3 and 6 years were measured one after the other in an interior with daylight lying on the floor, first with the PediaTape, then with the Zenfone AR. The two values were recorded. For further research and quality assurance, the weight of each child (with clothing) was also noted. It is a within-group design with one independent variable (measurement device) that adopts two values (emergency ruler, augmented reality app). An exemplary measurement is shown in Figure 2. For data protection reasons, the measurement for the illustration is simulated with a doll.

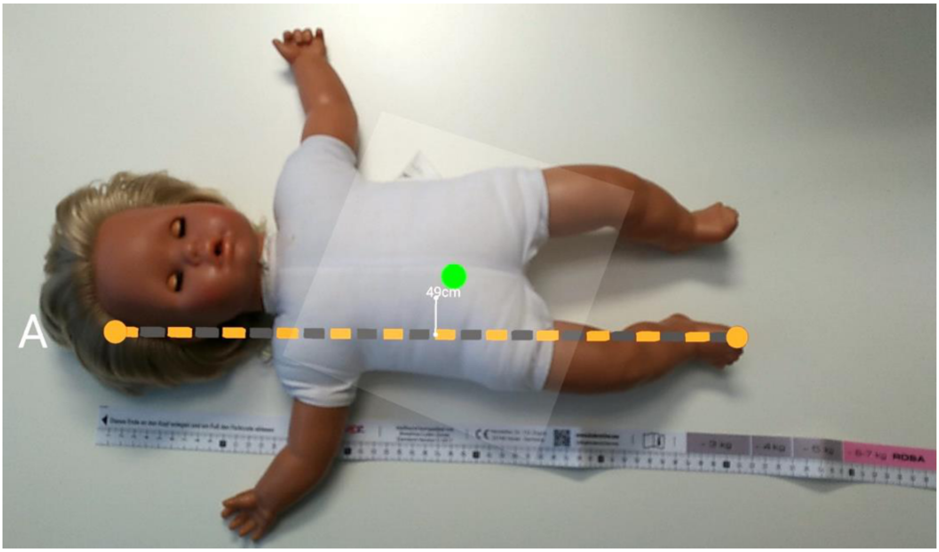


**Figure 2.** Screenshot of the re-enactment of the measurement with PediaTape and Augmented Reality App.

To compare two measurement methods of a variable and to decide if there is a significant difference between the two methods, the Bland-Altman's limits of agreement are best suited. The test is identical to the Tukey mean-difference plot [15], but became popular in medical statistics by Bland and Altman [16][17]. Thereby, the differences (delta)

$S_1$-$S_2$ of the individual measurements ($S_1$, $S_2$) are plotted against their mean ($\frac{S_1+S_2}{2}$). This results in the following graph for the diagram:

$$S(x,y) = \left(\frac{S_1+S_2}{2}, (S_1 - S_2)\right) \tag{1}$$

The upper and lower limits of agreement (LOA) are defined as $\bar{d} \pm 1.96s$ at a significance level of $\alpha = 0{,}05$ where $\bar{d}$ represents the mean difference and $s$ the standard deviation of pairwise differences. If 95% of the measurements lie within the LOA, both methods can be considered interchangeable, i.e. both methods are equally appropriate [17].

To check if a Bland-Altman Plot might be applicable, a one-sample t-test comparing the mean deviation of the difference ($S_1$-$S_2$) to the reference value zero was executed as preliminary work. In the optimal case, the difference of the individual measurements would be zero - then both measurements would be identical. The following hypothesis is tested:

$H_0$: There is no difference between an augmented reality app running on the Asus Zenfone AR and a PediaTape emergency ruler in the quality of measuring.

If there are large deviations, this means that there is a significant difference between the two measurement methods and a Bland-Altman plot would not be necessary.

## 3. Results

### *3.1. Related Work*

Although there is some interesting work done with commercially available depth cameras, such as hand gesture recognition [18], it is never evaluated how accurate these cameras actually are. But in the case of this paper and other cases, an exact measurement is the basis for further applied research. There are also various studies that attempt to solve the relevant and known problem of dosage errors in pediatric emergencies with the aid of an app [19][20][21]. But no attempt to automate the process of size recognition - and thus the basis of all calculations - is available. Some of these apps also use the age-based formula [19], which, according to the systematic review of Young and Korotzer, is less accurate than the size-based estimate [6]. All dosage apps found have in common that the values must be entered manually. However, these metrics must first be known (age, weight or height). There are also apps that aim to digitally map the analog emergency guidelines that are available [22].

### *3.2. Preliminary Work*

Table 1 and Table 2 show the results of the one sample t-test to test value = 0. There is no significant difference (diff) between the two measurement methods in the quality of measuring ($t$ = -1.022; $p$ = 0.314). The difference of the individual measurements does not deviate significantly from zero ($\overline{x}$ = 0.314; s = 2.044). $H_0$ can thus be retained.

**Table 1.** Difference (diff) between PediaTape and Augmented Reality App (in cm). One sample statistics (SPSS Output).

| | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| diff | 33 | -0.364 | 2.044 | 0.356 |

**Table 2.** Difference (diff) between PediaTape and Augmented Reality App (in cm). One sample t-test to test value 0 (SPSS Output).

| | | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| diff | -1.022 | 32 | 0.314 | -0.364 | -1.088 | 0.361 |

### *3.3. Bland-Altman's limits of agreement*

As can be seen graphically in Figure 3, at least 95% of the measurements are within the limits of agreement (Mean ± 2 Standard Deviation (SD)). Thus, it can be said that there is no significant difference in the quality of the two measurement methods in terms of size detection. In most cases (15 of 33; 45%) there was a deviation of 0 to 1 centimeter, in 25 cases (75%) the deviation was two centimeters or less. Deviations greater than three centimeters were rare (3 of 33; 9%). There was no variation greater than 5 centimeter.

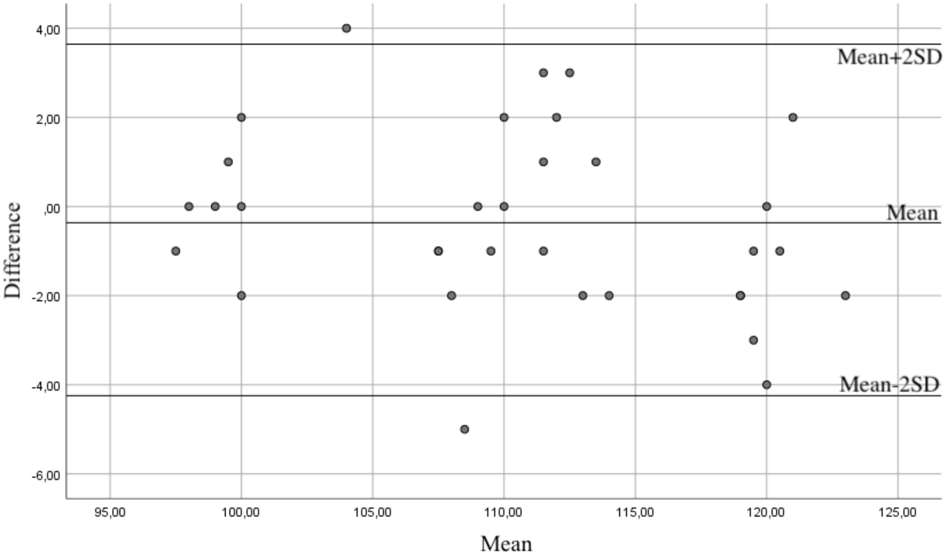


**Figure 3.** Bland-Altman Plot.

To exclude a proportional bias a linear regression can be made. For this purpose, the mean (mmean) is tested for hypothesis H:

H: The coefficient of mean is zero.

As can be seen in Table 3, the t value is not significant ($t = -1.389$; $p = 0.175$). Thus, H can be maintained. Within the available data a proportional bias can be excluded.

**Table 3.** Linear regression to test for proportional bias for dependent variable difference (diff). SPSS Output.

| | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|
| **Model** | **B** | **Std. Error** | **Beta** | **t** | **Sig.** |
| (Constant) | 6.783 | 5.158 | | 1.315 | 0.198 |
| mean | -0.065 | 0.047 | -0.242 | -1.389 | 0.175 |

## 4. Discussion

Figure 3 shows graphically that there is no significant difference between the measurement of the augmented reality app and the emergency ruler to the significance level $\alpha = 0{,}05$. This is also confirmed by the t-test carried out in advance (Table 1 and Table 2). However, it should be noted that the sample size (n = 33) is only slightly above the rule of thumb proposed by Hogg and Tanis, among others, that for a sample size of 25 to 30 participants it can be assumed that the central limit theorem applies and that the sample is normally distributed [23]. Nevertheless, it can be seen that the measurements vary only in a few cases. As the linear regression shows, the measurement quality does not depend on the size of the child (Table 3).

It must also be considered that even emergency rulers only give approximate weight estimates. These vary between one and six kilograms depending on the size of the child (PediaTape). This weight is ultimately critical to the dosage of medication and other procedures.

This result confirms that the measurement with an augmented reality app on a smartphone with depth camera (Asus Zenfone AR) provides good results indoors and allows further applied research with the equipment. It should be noted that daylight can influence the measurement with infrared sensors. This has to be tested in further studies. At this point it should also be noted that Google discontinued its ambitious AR project Tango in March 2018 in favor of the new technology ARCore. Due to the expensive additional hardware required (depth camera with infrared sensor), it was not able to assert itself [24]. However, the libraries are still available in the Google Archive [25] and the hardware is still for sale [26]. ARCore, as well as Apple's competitor ARKit 2 [27], can be used on many current smartphones. For exact AR applications, however, the use of a depth camera is necessary.

The long-term goal is of course to provide an assistance service that can be used in the event of a pediatric emergency. Further questions need to be clarified, for example whether automated size recognition can take place with the help of machine learning. The app would have to be able to classify people (children) without errors and then calculate the size with the help of the depth camera. It is also possible to imagine that there would then be intelligent in-situ support that would guide the user through the acutely necessary process on the basis of the guidelines and would also, for example, provide operating assistance for medical technology. This can then be displayed at the right time. Such intelligent assistance services have, for example, been researched in the project A.L.I.N.A. [28] funded by the German Federal Ministry of Education and Research (BMBF). It would also be helpful for operation during an emergency if the assistance service was not running on a smartphone but on a head-mounted display. This requires further research in this area, especially in the area of usability.

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