Abstract: In the last decades, an alarming rise in prevalence of childhood overweight and obesity has been observed which is partly attributed to a lack in physical activity and has started to become a public health concern. Therefore, the necessity for accurate physical activity assessment has become more and more apparent. Physical activity can be assessed objectively using accelerometers or combined devices. The application of such devices is sometimes complex and wearing the device may influence the behaviour of the test person. Therefore, assessment without any worn device would be an advantage.

A RGB-D camera device captures motion of the test person in a specific measurement area. After reducing the data and subtraction of the voxel distance, an activity level can be calculated. The calculated activity level is similar to acceleration data of common monitoring devices. The calculated activity level is the sum of the person’s activity. Little activity with small movement can be differentiated from intense activity with large movement and high acceleration as well as no activity. The data can be structured in body-activity and limb-activity. Classifying those categories increases the benefit of this assessment compared to common accelerometers.

With the RGB-D based assessment objective, contextual information of different physical activity levels can be provided. Physical activity assessment without a worn device offers advantages such as the lack of manipulation of the device and its positioning, also the person’s compliance is no issue influencing the assessment. The RGB-D based assessment is similar to acceleration data and can be converted into comparable data and units after calibration. For more specific assessments a validation with accelerometers and the calibration of the derived data is necessary.

Keywords: activity assessment; 3D-based; indoor

Introduction

In the last decades, an alarming rise in prevalence of childhood overweight and obesity has been observed which has started to become a public health concern [5]. Obesity often persists into adulthood [3] increasing children’s risk of developing non-communicable diseases such as type 2 diabetes and cardiovascular disease [2]. In recent years, the amount of people suffering from non-communicable diseases has risen continuously leading to the principal cause of death in the world [6]. Since a substantial amount of those diseases are attributed to a lack in physical activity, the necessity for objective and accurate physical activity assessment has become more and more apparent.

Up to now, accelerometers are an often used and well-established instrument for objective assessment of habitual physical activity in large samples under free-living conditions [4]. These devices register the intensity and duration of body acceleration. Hereby, energy expenditure is used as the main parameter to assess physical activity. Conclusions can be drawn based on where the accelerometer is positioned. Main issue – next to compliance and positioning of the device – is that accelerometers only record part of the relevant activities but not all bodily movement [1].

In order to avoid this, an improvement could be achieved by a system which recognises not just bodily movement but also offers contextual information (activity index) allowing a precise calculation of energy expenditure on basis of visual tracking.

1.1 Visual tracking and analysis

The here proposed visual tracking is based on an RGB-D camera device to trace a single person’s movements without any worn device for indoor measurement. The camera system has the ability to track the children’s position and calculate their activity.

During development, first the calculation algorithm is tested in a predefined measurement area, so the action area for each child is strictly limited. The movement in this measurement area is analysed, actions outside this area
cannot be analysed (Figure 1). This restriction is necessary to enable a repeatable setup for the testing of the calculation algorithm. In a first test setup the scenario is limited to classroom conditions: indoor, nearly fixed positions, constant lightning and at most 5 persons in one camera filed. In the next steps, the child’s position is tracked and the action area is calculated around the child, so the action area becomes more and more moveable.

Figure 1: Tracking-Scenario in a classroom with children and teacher; here the child at the second desk is tracked and analyzed.

Figure 2: Activity frame as difference of two sequenced frames; black areas with a lot of activity, white areas with only small changes; activity index coded in gray scale from white to black; top-right – the RGB image of the analyzed person

The analysis is solely based on the depth data of the RGB-D device. The produced depth data is an array of distance values, resulting in a frame of which each point accounts for the distance between the sensor. This can be visualized as a gray coded image (activity frame) where distances are mapped onto different gray levels.

2 Calculation of the activity level

The algorithm enables calculation of the assessed activity in a predefined measurement area, in order to calculate different physical activity levels. The measurement area is a fixed “region of interest” (ROI) and defined as a cuboid around every single child. In a later stage, the ROI will be automatically tracked and fixed to each child.

Large changes are areas with high velocity or high dynamic. The activity frame (activity frame) is calculated with an element wise subtraction of depth values (Eq. 1).

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    \text{activity index} = \frac{1}{Y_{\text{max}} \times X_{\text{max}}} \sum_{Y} \sum_{X} \text{activity frame}(x, y)
\]

Calculation of the activity level is currently a post-processing step. Firstly, the difference of two sequenced frames has to be calculated which leads to activity frames. One activity frame is shown in Figure 2: intense activity or large changes between two frames are then visible as high values (black), static objects become invisible (Figure 2).

2.1 Analyse of calculated activity level

The analysis of motion detection and the classification is based on the sum of all elements in the ROI. The resulting sum vector is the major element of the classification and allows a fast categorisation in three groups (no movement, small movement and intense movement – Figure 3).

Due to the standardisation to the defined measurement area a flexible transfer to other settings and measurement fields is achieved. The activity level is the sum vector of all motions in the measurement field around a centre point. The activity level does not offer any information about the position of the activity in the measurement field. To get the position additional small measurement fields have to be defined around one child.

3 Results

The simple analysis of the RGB-D data allows the classification of sequences without movements, small movements and intense movements. The activity index represents movements with contextual information; with more
than one ROI it is possible to locate the movement. Small amplitudes in the activity graph reflect small or slow movements. Fast movements with high dynamic result into high amplitudes in the activity graph.

In a mixed scenario with phases of intense and small movements the algorithm can detect start and stopping point of the movements (Figure 7).

Figure 4 represents a situation with no activity; the small amplitudes are just noise from the sensor.

In a scenario with small activity amplitude the activity index is bigger than the noise, resulting in an irregular signal and a low activity (Figure 5).

Higher activity in the scene is shown as a signal with higher amplitudes and higher standard deviation (Figure 6). This makes it easy to differ these three groups of activities.

The developed algorithm can detect activity levels in a scenario (ROI) for one child without a worn device. Fast movements with high dynamic can be differentiated from slow movements.

**4 Conclusion**

With the RGB-D based assessment, objective, contextual information of different physical activity levels can be provided. Physical activity assessment without a worn device offers advantages such as the lack of manipulation of the device and its positioning; also the person’s compliance is no issue influencing the assessment.

In further work a validation with accelerometers and the calibration of the derived data is necessary. The RGB-D based assessment seems to be qualitative similar to accel-
eration data. The acceleration sum data and the RGB-D based assessment have the same curve linearity and can be converted into comparable data and units after calibration.

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**Author’s Statement**
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**References**


