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# Smart toilet seat configuration for more autonomy using an AI-based 3D depth sensor

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## Introduction

The lack of suitable accessible toilets that are publicly available and which can be used without personal assistance stops older or disabled people from going out [1]. Despite a high need for individualised and well-tailored support and the toilet being a facility used by everyone on a daily basis, poorly designed public toilets do not meet the needs of people with disabilities [2]. We present a concept for a motorized toilet controlled by software in order to move to certain positions based on ICT. The utilized 3D sensor provides privacy protection as well as emergency detection by recognizing falls and forwarding alarms. The proposed approach is an autonomy supporting solution addressing ageing people and persons of all ages with disabilities and their needs when using a toilet outside home.

## State of the Art

A major challenge for handicapped persons is standing up and sitting down on the toilet [3]. Solutions with higher seat height lead to increased straining and time on the toilet due to a disadvantageous posture [4]. If the feet are not fully touching the ground, this can also cause a less stable sitting position [5].

Wheelchair users are also to be considered with their transfer needs. Apart from handles on the toilet, which require strength and leave the toilet height unchanged, there are also manually configurable lift units, usually requiring the use of remote controls to set the toilet heights. As a result of a requirements collection phase with 300 users in Belgium, the Netherlands, Poland and Romania, needs and wishes of potential users were analysed [6]. One of the conclusions was that a smart toilet should offer adaptation possibilities without the need for the user to control every single function, thus reducing the complexity. Also, costs for adapting a standard accessible toilet should be kept low. The demands on robustness are higher in the public or semi-public area than in the home area since there is a constantly changing user group with largely varying needs.

We use an AI based system that adapts automatically to the user's needs and additionally offering safety features.

The sensor measures the height of a person and then moves to the corresponding height and tilt. Since the configuration is done automatically, no user interaction is required. For person location and pose detection, only the depth sensor is used, providing privacy in the toilet area. A deep learning approach enables to classify between a person sitting and standing. This allows to detect persons sitting in a wheelchair (see Fig. 2). The Random Forest classifier is tailored to toilet rooms, trained on a large-scaled training data set of 30,000 samples. Based on the distance, height and posture of a person, the toilet seat can then be adjusted accordingly.


Fig. 2: 3D depth image of a person in a wheelchair.

The 3D depth images are analysed in real-time on a Raspberry Pi. The sensor and the toilet lift unit communicate via an MQTT protocol, allowing the transmission of height and location data between the two components. Additionally to the automatic toilet lift pre-configuration, the 3D sensor can detect emergencies like falls. When a person is lying on the ground within the sensor's field of view, an alarm can be provoked and forwarded.

## Proposed Solution

We present a smart AI toilet consisting of a toilet seat equipped with a lift unit, and the CogvisAI 3D sensor (see Fig. 1). A motorised toilet seat, able to support the stand-to-sit and sit-to-stand transition, is placed over a standard toilet bowl.


Fig. 1: CogvisAI sensor (left) and smart toilet lift unit (right).

## Conclusion

This smart toilet will contribute to the active life of older and impaired persons, making it easier to leave home and participate in social activities. This supports autonomy and participation and thus, will contribute to independence and quality of life. A next step will be the implementation of a prototype that can be installed at public pilot sites like shopping malls, restaurants or hotels.

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