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Needs Assessment for an Assistance System for the Visually Impaired and Blind in Climbing and Bouldering

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Abstract. Background: This thesis deals with the potentials and challenges of climbing for blind and visually impaired people. Objectives: The extent to which an innovative technical assistance system can contribute to supporting this sport in climbing gyms is analyzed. Methods: As part of this study, a needs analysis was carried out using a mixed methods approach. This comprises an observational study, expert interviews and a quantitative survey of the potential target group. Results: The studies show that climbing can promote the development of social and physical skills. Nevertheless, there are needs and challenges, such as finding the next hold on a route. Conclusions: The technical assistance system could provide support by addressing these specific challenges and needs of blind and visually impaired people when climbing and supporting them with acoustic signals.

Keywords. disability studies, readiness for use, sports for persons with disabilities, technology, blindness

1. Introduction

The article deals with the topics of *active and assisted living/assistive technologies* and the *evaluation and usability of dHealth applications*. It describes an evaluation study for an assistance system for indoor climbing for visually impaired and blind people.[2]

Sport and exercise promote endurance and coordination as well as self-confidence, which can have a strong positive impact and physical and mental health. With the help of appropriate adaptations and aids, people with visual impairments have access to numerous sports, including climbing. Climbing has been particularly popular in the disability community as it helps to improve strength, mobility and body awareness, especially for the blind and visually impaired [1]. Paraclimbing will also be included in the Paralympic Games for the first time in 2028 [2]. While climbing usually involves the use of a rope, bouldering is done at jump height without a harness or safety rope.

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[2] Slight visual impairment: visual acuity of 30% to 10%, Significant visual impairment: visual acuity of 10% to 5%, Severe visual impairment: visual acuity of 5% to 2%, Blind: visual acuity of less than 2%.

Active blind and visually impaired climbers sometimes use assistance systems to help them practice the sport, where acoustic support plays a major role. Assistance systems like these already exist for running and swimming, which are comparable to climbing due to their clear directional specifications and as individual sports. Typically is the collection of data about the environment or location, for example, through a camera. This data is then processed to provide the athlete with helpful feedback, which is transmitted either by touch, hearing, or both.

Within the scope of a dissertation, an acoustic assistance system for visually impaired climbers is being developed. The system consists of a three-dimensional visual recording unit, whereby a camera and other sensors capture the image data. For this purpose, a headband, similar to a headlamp, is used. The data is then forwarded to a processing unit, where the acoustic signals is generated and transmitted to the climber via headphones so that information about the next hold can be obtained by listening to the direction of the synthetically generated sound (Figure 1). The processing unit analyzes the gathered image data by using positioning algorithms and AI approaches to recognize the exact position and distinguish different shapes and colors, with the latter playing an important role to recognize the holds which are part of the current route. The signals are received via headphones so that the climber can be guided to the next hold by locating its spatial position acoustically as if the holds were actually emitting a signal. The climber's HRTFs (Head-Related Transfer Functions) are used for this purpose [3].

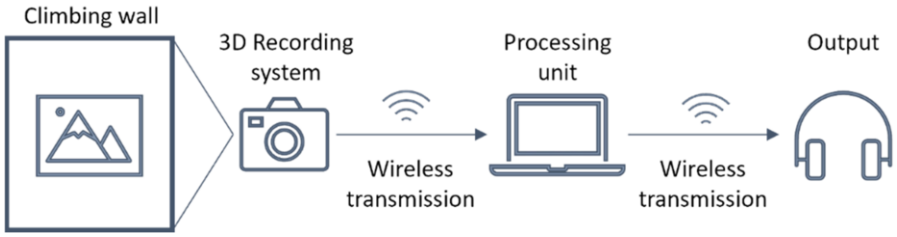

Figure 1: Block diagram of the assistance system: recording with camera and other sensors, wireless transmission of the data to a computer, where the acoustic signals are calculated and wirelessly transmitted to headphones , own illustration [3].

The social science evaluation study presented here as part of a master's thesis [4] explores which factors need to be taken into account when developing and optimizing a new assistance system for blind and visually impaired people. The focus of this preliminary study is on the field of climbing and bouldering to meet the needs and requirements of the users. The results will be used for the evaluation and needs analysis for the development of the assistance system.

2. Methods

2.1. Observation

Three methodological approaches were combined to collect data, the first of which was (participant) observation [5]. It took place 2024 as a semi-standardized observation of children and adolescents with visual impairments climbing on a rope. The group of seven

people (n=7) took turns climbing on a climbing wall in a gym and were observed by two researchers with the consent of their parents. Although observation instructions were defined in advance, data collection tended to be open and unstructured. Categories were inductively formed from the observation protocol and evaluated using a summarized content analysis [6].

2.2. Interviews

Furthermore, expert interviews (n=2) were conducted with the two leaders of a climbing group based at a center for the visually impaired and blind, where one person is employed while the other is a member of a mountaineering association [7]. The guided interviews asked questions in four categories, for example, about experiences with blind and visually impaired climbers and the resulting needs and requirements. In addition, both interviewees gave feedback on the planned assistance system presented. The interviews were recorded and transcribed according to the content-semantic rules [8]. The evaluation was carried out using deductive-inductive category formation and qualitative content analysis [6].

2.3. Questionnaire

The sample was drawn from the distribution list of a centre for the visually impaired and blind (n=13). A standardized questionnaire with 26 questions, mostly Likert scales, was created for the evaluation study. The survey was created as an online survey with soscisurvey. The deliberate selection of the participants was based on the criteria of region, visual impairment or blindness and climbing experience [9]. As we perform a preliminary exploratory case study to identify requirements for the assistance system, and as the size of the population of potential users is limited, we survey a relatively small number of participants. Descriptive statistical methods were used for the analysis.

3. Results

3.1. Observation

Overall, the climbing situation observed took place in a benevolent, friendly, supportive and thoroughly humorous atmosphere. One participant expressed this with the words "I enjoyed it". In addition to the directly visible and observable enjoyment of climbing, stories told by the participants indicate that the activity has the potential to strengthen self-confidence and self-esteem. Next to these social and positive interactional aspects such as support and community experience, some situations were observed from which opportunities to improve climbing processes using technology can be derived. Overall, it is noticeable that assistance is given acoustically by the instructors, whereby the system of clock positions is used: "P[3] is already climbing, I is belaying and gives instructions according to clock positions and whether the foot needs to be higher".

The new system could be used in relation to these similar recurring instructions from the group leader. The function of the assistance system would be to take over the task of

[3] P stands for participating persons, I for an instructor.

guiding people to the correct handles. This would give blind and visually impaired climbers more autonomous freedom of action and they would be less dependent on external instructions. A further result is that, in addition to finding the holds, finding the footholds is also important. The very worn-out climbing shoes observed show that "P usually look for the footholds with their feet by scraping along the wall until they find a foothold". However, the actual implementation of acoustic visualization of footholds requires further research and development.

3.2. Interviews

In the two expert interviews conducted, the interviewees described their experiences of carrying out climbing activities with blind and visually impaired children and young people.

According to the interviewees, blind and visually impaired people have a number of needs when climbing indoors, such as the possibility of receiving acoustic assistance. One specific problem is the background noise: "[I]t is also loud in the halls and if you cannot see, then this noise pollution is one of the biggest problems, because you can no longer hear the commands at all, which others often do via hand signals." Statements from the interviewees show that noise pollution in public climbing gyms is an important factor that restricts the participation of blind and visually impaired people in climbing. For this target group in particular, it is essential to be able to hear instructions, for example regarding the location of holds. "Of course, it would be ideal if you had handles that could communicate. [...] When you get close, they make a beep. That would be enough." This idea of reproducing the handles with acoustic signals is in line with the planned assistance system.

One result of the survey that should be noted is that visually impaired people have developed different strategies and abilities to perceive and navigate their surroundings. According to the interviews, blind people tend to use tactile perception when climbing, while people with visual impairments have a visual approach, which is why one interviewee can imagine the assistance system being more suitable for people with visual impairments.

The results show that such a system could, in principle, make a significant contribution to improving the participation and autonomy of people with visual impairments or blindness in climbing sports. The questions of who the system is better suited for, i.e. people with visual impairments or blindness, and whether the system could be equally suitable for climbing and bouldering, could not be definitively answered. This would have to be evaluated through further surveys and tests. It was also not possible to definitively clarify the assumption regarding possible acceptance or rejection, so it is advisable to seek direct input from the target group. The technical implementation would also have to be tested, checked, and evaluated separately in order to assess whether it is helpful and can be put to use.

3.3. Questionnaire

The questionnaire survey confirms that climbing can be seen as a relevant and interesting sport for people with blindness or visual impairments. The setting in which climbing used to take place is specific climbing groups for people with disabilities. The color of the holds in particular was seen as a challenge (50%), but also orientation (50%) and being dependent on outside help (41%). Finding the holds was a challenge for 30%.

Other aspects such as body position, moving hands and feet, the difficulty of the route and estimating strength were less challenging. Some challenges are compensated for by the instructions and help from sighted people.

Even though the majority of respondents do not use assistance systems in everyday life yet, 61% state that they would find it easier to find a hold that makes a sound when climbing. 63% would be prepared to try out such a system (Figure 2[4]).

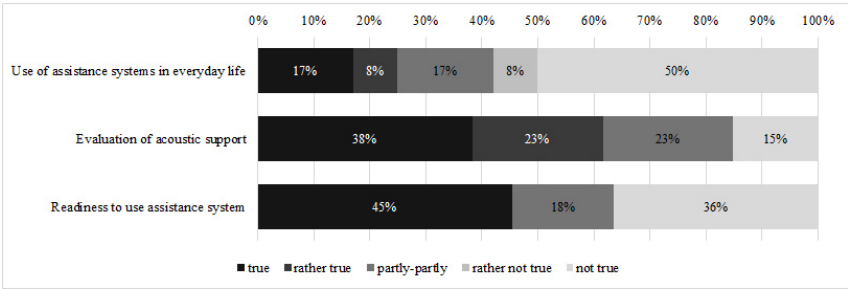

Figure 2: Need for a climbing assistance system and willingness to use; own illustration.

In terms of determining the target group for the evaluated assistance system, it was found that the challenge of recognizing the handle color is a challenge for the majority, but not for everyone. This means that there may be a greater need for people with blindness, which could be compensated for by the assistance system. In terms of willingness to use, the answers are roughly similar for both blind people and people with visual impairments. Research with a larger number of questionnaires could provide more significant results regarding these correlations. This could reveal which target group the system is best suited to, but would also bring attention to the respective needs and requirements.

4. Discussion

There are various approaches to support systems for climbing for people with visual impairments, for example systems based on haptics and vibration [10]. In contrast, the system presented here is characterized by acoustic signals and the evaluation study by the inclusion of the user group. Overall, it has been shown that a needs assessment in advance is useful to increase usability and acceptance, also which is in the spirit of user-centered design.

The study identified sport as an important activity for people with blindness or visual impairment and climbing in particular as a suitable and popular form of exercise for this target group.

In relation to the research question regarding needs and requirements in this sport, challenges for climbers could be identified, in particular recognizing the color of holds and searching for the next hold, where precise acoustic instructions from assistants regarding the position of hand and footholds and thus the necessary movements are

[4] Question formulations: I often use electronic assistance systems in my everyday life. If the handle made a sound, such as a click, I could find it more easily. I would use a new electronic, acoustic assistance system for climbing or bouldering.

required. [11] The evaluated system offers an alternative user interface in terms of universal design [12]. The system could thus increase autonomy, self-efficacy and inclusion when climbing.

Another result is the importance of the social component of climbing, combined with the potential for social inclusion. The assistance system could facilitate social access to other climbing groups for blind or visually impaired people, as it reduces the dependency on help and thus power relations and hierarchical differences [13] and thus promotes interaction with non-disabled climbers and inclusion. The research results of the various methods do not coincide in all aspects. In the expert interviews, bouldering tended to be classified as unsuitable for the target group due to the increased risk of injury caused by unsecured jumping off and the reduced fun factor caused by the low height. In contrast, the number of boulderers participating in the survey was higher than that of indoor climbers. The area of application of the assistance system is therefore not limited to indoor climbing, but could also be used for bouldering. Opinions are divided when it comes to willingness to use the system. Both in the two interviews and in the results of the questionnaire, around half of the people stated that they would use the assistance system, while the other half said they would not.

One limitation of the evaluation study is the relatively small number of cases. The next step regarding future research is to have the developed system tested by volunteers. Subsequently, further research could focus on evaluating the usability of the system in other areas and different sporting contexts.

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