Quantitative Approach of Remote Accessibility Assessment System (RAAS) in Telerehabilitation

Shinyoung Lim[1], Jongbae Kim[2], Uzoh Ikpeama[1], Erik Porach[1], Robert Dale Lynch[3], and David M. Brienza[1]

[1] Department of Rehabilitation Science and Technology, Rehabilitation Engineering Research Center on Telerehabilitation, University of Pittsburgh, PA, 15260, U.S.A.
{sylim,uzoh,eap26,dbrienza}@pitt.edu
[2] National Rehabilitation Center - Research Institute, Seoul, Korea
jbkim@nrc.go.kr
[3] FAIA, Architectural Expert & Consultant, Haymarket, VA 20169, U.S.A.
bob@robertdalelynch.com

Abstract. Assessing the accessibility using 3D Virtual Reality and telecommunication technology has influenced home adaptation to improve accessibility in homes for individuals with disabilities, especially with Spinal Cord Injury. To provide clients with quantitative ideas on home adaptation with levels of accessibility, we propose a tentative method of measuring accessibility in home. There are a number of assessment protocols to assist rehabilitation professionals and architects in gaining wheelchair accessibility. In this paper, we briefly introduce quantitative assessment method of wheelchair accessibility in home. The feasibility of mathematical expressions of the quantitative accessibility was discussed.

Keywords: accessibility assessment; tele-rehabilitation; mobility issues.

1 Introduction

The motivation of quantitative approach in accessibility assessment is to provide rehabilitation professionals and architects with objective evidence for home adaptation or renovation to improve wheelchair accessibility in home while rehabilitation professional and architects are located remotely by using tele- rehabilitation technologies. Quantitative measurement methods of wheelchair accessibility in home provide rehabilitation professionals, architectures, and wheelchair users with an opportunity to verify space for renovation in their homes and eventually give a clear idea on investment and payment for enhancing accessibility for their Activities of Daily Living (ADL).

In this paper, we briefly introduce mathematical rationales that have been used to measure accessibility, proposed mathematical expressions, measuring accessibility based on a few activities of daily living (ADL) in home with small number of human subjects are also discussed.

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2 Mathematical Rationale

Most of the evaluation items on the 'Evaluation Form for Accessibility Assessment' developed for conventional in-person assessment, require an answer of yes, no or not applicable. Architects and rehabilitation professionals depend on non-numerical expressions of accessibility assessment with a few activities of daily living (ADL). The motivation of quantitative approach stems from the needs of objective and reasonable facts of accessibility in home adaptation for individuals with mobility issues.

Assessing accessibility has been a long term issue in most accessibility protocols because each model is either too simple that leaves things out or too complex for most individuals to follow [1, 2]. After analyzing related numerical expressions of measuring accessibility, a relevant numerical expression for a quantitative approach of wheelchair accessibility is proposed as:

$$Accessibility = \sum_{I}^{J} \left(\frac{Distance * Time}{Routes}\right), \tag{1}$$

where I is the starting locations and J is the destination locations. Equation (1) measures distance in meters and time in seconds. Routes refer to the number of reasonably available paths to get from one location to another. With this simple equation, the measurement is an easier and more straightforward method when compared to the other methods. Distance and time are two vital components when determining accessibility, although the number of routes available to get from point A to point B should be considered critical as well. If there is more than one route from a starting location to a destination location, the distance and time values used need to be averages. The results of equation (1) are able to be applied to individuals in wheelchairs without further adjustments. A lower accessibility value means a greater accessibility gains. As equation (1) leaves a discrete number value, relative accessibility assists professionals to clearly understand its meaning of accessibility compared by regular division:

$$\text{Relative Accessibility (of A to B)} = (\text{Accessibility}_A \ / \ \text{Accessibility}_B) \tag{2}$$

3 Method

A photo and a floor plan, shown in figure 1, of the building were used to develop service scenarios in activities of daily living (ADL). The investigation was carried out at a smart house owned by Blueroof, an industry partner focusing on state-of-the- art living technology to provide a safer home environment as shown in figure 1. To collect data for assessing accessibility, a very small subject pool carried out the investigation. It consisted of two individuals with no mobility issues, one to navigate through the scenarios and one to measure the required data. Authors use a manual wheelchair to measure accessibility.

The route for the first scenario was marked on floor plan printouts in figure 2. This was transferred to the actual house using tape guidelines that indicated the desired path. After marking the house to comply with the marks on the floor plan, the total

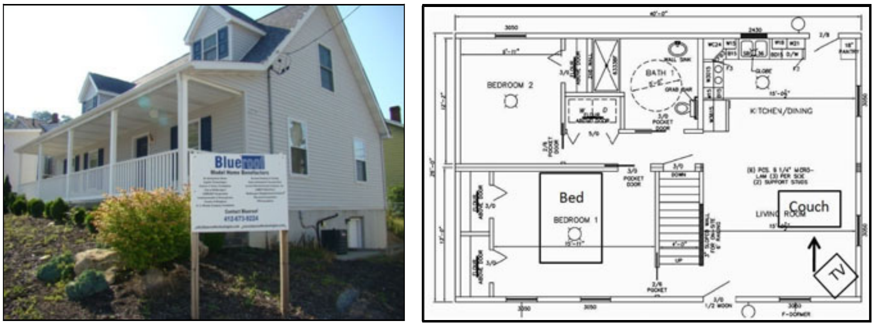

Fig. 1. Floor plan of Blueroof House located at suburban area of Pittsburgh, PA

distance of the route in the scenario was measured and recorded in meters. In this short paper, we introduce one scenario among six scenarios developed based on most frequent activities of daily living in home as described in table 1 and routings of the scenario is also shown in figure 2.

Table 1. A Scenario of Activities of Daily Living (ADL): Waking up, shower, and breakfast

Amy has just woken up to the aroma of blueberry pancakes floating through the house. Anticipating a delicious breakfast, she gets up and heads over to the bathroom to rinse her face and hands before ending up in the kitchen for breakfast.

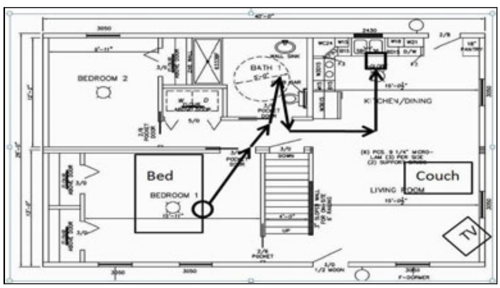

Fig. 2. Routing path with marked nodes

4 Results

Table 2 shows the results of measuring accessibility. The values were calculated using equations (1) and (2), with times and distances varying but the number of routes remaining constant at 1. On foot traveling was done with about the same ease throughout all areas of the house. However, differences were noticed during wheelchair travel. There was an issue that the maneuvering space available in the hallway, which didn't leave an adequate turning radius to get to the bedroom or bathroom in the wheelchair. The scenario had difficulty in making a "U" turn, and the carpet in the bedroom seem to create even more resistance than the one in the living room.

Table 2. Results of Accessibility Measurements

Wheelchair Accessibility (Subject A)	625.11
Wheelchair Accessibility (Subject B)	699.05
On Foot Accessibility (Subject A)	256.70
On Foot Accessibility (Subject B)	226.47
Relative Accessibility by Subject A (Wheelchair to On Foot)	2.44
Relative Accessibility by Subject B (Wheelchair to On Foot)	3.09
Routing Distance (m)	12.44
# of Routing Nodes	7

5 Conclusions

In this paper, we introduce a mathematical rationale for assessing quantitative accessibility and testing results using individuals in wheelchairs and individuals without disability in a home environment. A real world implication of this approach will be a cost effective method for measuring accessibility, as well as a way to determine to what extent modifications are needed in the home. The proposed expression will be assisting rehabilitation professionals and architects to assess accessibility using the telerehabilitation protocol. Further studies including a larger subject pool with actual users of wheelchairs in measuring accessibility as well as accessibility grades that will be acceptable and standardized to provide a threshold for home adaptation to improve wheelchair accessibility in homes.

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