Project Plan for Thesis Projects

Department of Computer Science and Media Technology

General information

Title	AI-Based Screening of Sit-to-Walk Movement Quality Using Skeleton Avatar Technique
External company:	None

Persons involved

Student 1:	Rula Nayf	rn222qf@student.lnu.se
Student 2:	Vilgot Lundborg	vl222kz@student.lnu.se

Supervisor:	Alisa Lincke
External supervisor:	None

1. Background

Everyday movements such as standing, walking and maintaining balance are essential to independent functioning in daily life. With increasing age, changes in physical capacity, such as balance, strength and coordination, can lead to an increased risk of falls and contribute to other difficulties that may limit independent living and increase the need for assistance. Supporting the maintenance of functional movement is therefore important from a healthcare perspective. Research shows that regular physical activity can have positive effects for older adults, including reduced risk of falls and various other health benefits [1].

In addition to the ability to perform a movement, how a movement is executed is also relevant for maintaining physical functioning in daily life. Previous research has shown that increased awareness of one's own movement behaviour can play an important role in supporting improvements in movement patterns over longer periods of time. In particular, methods involving video-based tools that offer feedback to the user have been shown to be effective for this purpose [2,3].

2. Motivations

Population ageing presents a significant global challenge, making it essential to support older adults in maintaining their physical function and independence. Early identification of subtle movement problems and the availability of timely, accessible interventions are therefore critical. This thesis aims to link expert-based Observational Movement Analysis (OMA) and automated computer vision.

OMA provides a rich, clinically grounded framework for interpreting movement quality, but it is time-consuming and depends on a specialist's expertise. At the same time, previous research has shown that combining the subjective reflection with video-based visual feedback of their own movements can increase engagement in rehabilitation and self-care among older adults [3-5]. The Skeleton Avatar Technique (SAT) has previously shown effectiveness in measuring physical activity and predicting balance ability using movement tests recorded with smartphones [6-8]. More recently, machine learning methods have shown strong potential for detecting movement problems such as postural orientation errors during functional tasks [9]. This work is therefore motivated by the integration of reflective video feedback with automated, AI-based movement analysis, as recently proposed by the research group in an accepted (in-press) study focusing on AI-trained screening tools for sustainable physical functioning in daily life.

3. Problem Statement

Although both expert-based movement assessment and machine-learning-based movement analysis have shown promising results, they are typically applied independently rather than within a unified screening tool suitable for everyday use [2, 7-8]. As a result, user reflection, expert assessment, and automated analysis are often addressed separately rather than within a single coherent framework [2,3].

This thesis addresses the challenge of designing a system to approximate expert-based OMA scores based on video-derived SAT data using machine learning techniques. The aim is to explore whether integrating SAT recordings with expert-based OMA enables accurate assessment of movement quality during the sit-to-walk movement.

4. Research Questions

To investigate the integration of expert-based and automated movement analysis, this thesis is guided by two research questions:

RQ1. *Which modeling approach best predicts physiotherapist-based Observational Movement Analysis (OMA) assessments of the sit-to-walk movement using Skeleton Avatar Technique data at the levels of movement aspects, phases, movements, and participants?*

This question aims to identify the most accurate AI model for replicating expert clinical judgment from video data.

RQ2. *To what extent do physiotherapist-based Observational Movement Analysis assessments and Skeleton Avatar Technique–based movement measures of the sit-to-walk movement relate to instrumented movement analysis data from MoLab and RSscan?*
This question examines the relationship between video-based and observational movement assessments and established instrumented kinematic and kinetic measurements to evaluate whether SAT and OMA-based measures reflect biomechanically meaningful movement characteristics.

5. Method

This thesis is conducted as a controlled experimental study combining expert-based Observational Movement Analysis (OMA), video-derived Skeleton Avatar Technique (SAT) data, and machine learning techniques. The overall approach is to use the SAT data as the predictors, together with the OMA assessments as the response variable, to train machine learning models to approximate the expert-based OMA assessments. To address RQ1, different machine learning approaches (architectures, hyperparameters etc.) will be compared to evaluate their ability to predict the expert scores. To address RQ2, the relationship between the model predictions, OMA assessments, and instrumented movement analysis data will be analysed.

This study is based on an existing dataset collected in a controlled experimental setting, consisting of three main data types: video recordings together with corresponding SAT data, expert-based OMA assessments, and instrumented movement analysis measurements. The dataset was obtained from a small group of adult participants performing standardized movement tasks under controlled conditions. Movements were recorded using a video camera and were later assessed by licensed physiotherapists. In parallel, instrumented movement analysis data were collected during the same sessions.

Video recordings were used to derive SAT representations, which describe human movement using joint positions extracted from the recordings. These representations capture both spatial and temporal characteristics of the performed movements and provide the primary input data for the machine learning models.

Expert-based movement quality assessments were obtained using structured OMA performed by licensed physiotherapists. Using a standardized assessment protocol, the experts evaluated qualitative aspects of movement performance and assigned scores reflecting deviations from optimal movement execution. These expert-based scores serve as ground truth for training and evaluating the machine learning models.

In addition to video-based and observational data, instrumented movement analysis measures were collected to provide independent reference information on movement characteristics. Kinematic data were captured using the MoLab system, while pressure and stability measures were recorded using an RSscan pressure mat. Together, these instrumented measurements provide the data required for analysing the relationship between video-based, expert-based and sensor-based data.

For RQ1, machine learning models will be trained using the SAT movement representations as input data and expert-based OMA scores as target values. Several modelling approaches will be implemented and compared to examine how well expert assessments of movement quality can be approximated using different techniques. Model performance will be evaluated at different levels of aggregation, including individual movement components, movement phases, overall movement quality and participant-level performance. This comparison is intended to identify which modelling approach best captures expert-informed movement quality at different levels of detail.

For RQ2, the focus is on examining how different types of movement assessments relate to one another. Expert OMA assessments and SAT movement representations, including ML model estimates, will be considered alongside instrumented movement analysis data collected from MoLab and RSscan. By comparing observational and video-based measures with kinetic and kinematic data from the instrumented systems, the analysis aims to explore whether consistent relationships can be observed between these variables.

6. Expected Results and Contributions

The expected outcome of this thesis is a functional prototype of an AI-trained movement screening tool that uses video-based SAT data to assess the quality of sit-to-walk movement. Its output will be compared with expert-based OMA. The prototype is intended to show that OMA assessments can be predicted at different levels, including movement aspects, phases, and overall movement quality, demonstrating that structured movement assessment can be performed using video-only data in controlled settings.

This work contributes to the development of accessible, video-based movement assessment tools with potential use across different age groups, diagnoses, and functional levels. Specificly it provides a foundation for preventive monitoring among older adults, helping to support sustainable movement patterns and maintain functional independence. By integrating expert knowledge with automated analysis will this work establishes a framework for future research into scalable, AI-supported screening and prevention-oriented interventions.

7. Time plan

Date finished	**Milestone**	**Deliverables**

2026-02-06	Literature review & Background Research	Theoretical base (initial literature review)
2026-02-13	Project Setup & System Integration First draft	Development environment ready, first draft of introduction and background sections
2026-02-20	Data understanding & Preparation	Dataset explored and cleaned. Data preparation is documented in the report
2026-03-06	Experimental design	Initial experiment plan. Draft of the method section
2026-03-20	Model development for RQ1	Implementation of multiple modeling approaches for RQ1
2026-03-27	Model evaluation & comparison for RQ1	Comparative evaluation of RQ1 models
2026-04-03	Validation Analysis for RQ2	Analysis of the relationship between OMA, SAT and instrumented data
2026-04-10	Documentation draft	Draft of results and analysis sections
2026-04-24	Full draft	Full thesis draft with discussion and other adjustments
2026-05-08	Refinement	Revised thesis based on feedback
2026-05-22	Submission	Final thesis submitted

8. References

[1] F. C. Bull et al., "World Health Organization 2020 guidelines on physical activity and sedentary behaviour," *British Journal of Sports Medicine*, vol. 54, no. 24, pp. 1451–1462, Nov. 2020, doi: 10.1136/bjsports-2020-102955.

[2] S. Backåberg, D. Brunt, M. Rask, and C. Gummesson, “Experiences of using a video-based learning model during a long-term process of movement awareness and learning – a hermeneutical study,” *European Journal of Physiotherapy*, vol. 23, no. 1, pp. 41–47, Jul. 2019, doi: 10.1080/21679169.2019.1635639.
[3] S. Strandberg, M. Ekstedt, C. Fagerström, and S. Backåberg, “Cocreation of a video feedback tool for managing Self-Care at home with pairs of older adults: Remote Experience-Based Co-Design study,” *JMIR Formative Research*, vol. 8, p. e57219, Sep. 2024, doi: 10.2196/57219.
[4] J. Olovsson, M. Ekstedt, C. Fagerström, P. Bergman, and S. Backåberg, “Exploring health care professionals’ perspectives on using video feedback and movement analysis to facilitate physical functioning for older adults living at home: Co-Design Approach,” *JMIR Formative Research*, vol. 9, p. e73527, Nov. 2025, doi: 10.2196/73527.
[5] J. Simmich, M. H. Ross, and T. Russell, “Real-time video telerehabilitation shows comparable satisfaction and similar or better attendance and adherence compared with in-person physiotherapy: a systematic review,” *Journal of Physiotherapy*, vol. 70, no. 3, pp. 181–192, Jul. 2024, doi: 10.1016/j.jphys.2024.06.001.
[6] S. Backåberg et al., “Evaluation of the Skeleton Avatar Technique for assessment of mobility and balance among older adults,” *Frontiers in Computer Science*, vol. 2, Dec. 2020, doi: 10.3389/fcomp.2020.601271.
[7] A. Lincke, C. Fagerström, M. Ekstedt, W. Löwe, and S. Backåberg, “Skeleton avatar technology as a way to measure physical activity in healthy older adults,” *Informatics in Medicine Unlocked*, vol. 24, p. 100609, Jan. 2021, doi: 10.1016/j.imu.2021.100609.
[8] A. Lincke, C. Fagerström, M. Ekstedt, W. Löwe, and S. Backåberg, “A comparative study of the 2D- and 3D-based skeleton avatar technology for assessing physical activity and functioning among healthy older adults,” *Health Informatics Journal*, vol. 29, no. 4, p. 14604582231214589, Oct. 2023, doi: 10.1177/14604582231214589.
[9] J. Ä. Nae, M. Banega, F. Kronström, A. Jakobsson, M. W. Creaby, and E. Ageberg, “Evaluation of the ability of Machine Learning-Models to assess postural orientation errors during a Single-Leg squat,” *JOSPT Methods*, vol. 1, no. 1, pp. 17–29, Jan. 2025, doi: 10.2519/josptmethods.2024.0086.