In-Home Monitoring: A multi-modal, pose-tracking system for automated activity

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BACKGROUND

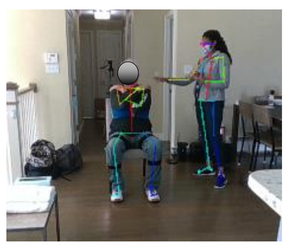
- Functional movement evaluation is often used to assess and monitor changes in mobility, but its value depends on proper administration and impartial scoring.
- Many of the patients for whom these assessments are needed are homebound. Therefore, we built and examined the precision of an at-home movement monitoring system created to recognize various functional tasks and automatically rate performance.
- If incorporated into clinical practice, our combined IMU-vision system could offer the opportunity to identify deterioration, prevent falls, and decrease healthcare utilization.

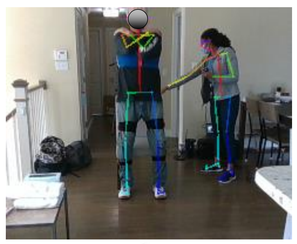
STUDY AIMS

- Identify functional activity being performed by the patient.
- Provide an objective assessment of the user performance.
- Evaluate the feasibility and accuracy of applying the system's autonomous activity-recognition recognition to analyze functional data collection.
- Evaluate the accuracy of the system's autonomous activity-scoring capabilities.

METHODS

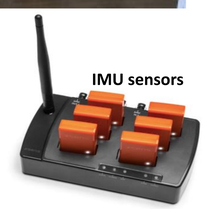
- Fifty community-dwelling adults completed sit-to-stand, standing balance, and walking assessments, all graded using the Short Performance Physical Battery (SPPB).
- Assessments were identified and scored manually and by the multimodal activity recognition and assessment algorithms trained on lab-based biomechanical data, integrating wearable inertial measurement unit (IMU) and external RGB-D Vision data.





Open-pose images | RGB-D data

RGB-D Camera



IMU sensors

Statistical Methods:

- Inclusion criteria included age ≥ 18, a completed course of acute care in a Home Hospital program, residing within a 15-mile radius of Boston, providing written informed consent, and communicating with study staff.
- A chi-square test evaluated differences in task-detection accuracy across the three subtasks of standing, sit-to-stand, and walking.
- For score accuracy, the intra-class correlation coefficient (ICC) evaluated the accuracy of system-generated clinical scores compared to ground truth data (SPPB scores completed on site).
- A chi-square test was also used to evaluate differences in score accuracy across the three subtests of side-by-side, semi-tandem, and gait speed.

An at-home multimodal pose-tracking system recognizes various functional tasks and automatically impartially rates performance.

RESULTS

Table 1: Study Population

Participants	n = 50	Living Situation	
Age, mean (yrs)	59	Lives alone	23%
Female	47%	Lives with spouse/partner	21%
Race/Ethnicity		Lives with spouse/partner and family	36%
White	56%	Lives with non-spouse family	13%
African American	26%	Other	7%
Latin@	9%	Education Level	
Multi/Other	9%	Less than high school	4%
Primary Language		High school graduate/GED	34%
English	85%	Some college	24%
Spanish	9%	College graduate	17%
Creole	2%	Post-graduate education	19%
Other	4%	Other	2%
Partner Status		Smoking status	
Single	26%	Never	45%
Married	51%	Former smoker	47%
Domestic Partner	4%	Active smoker	8%
Divorce	6%	Use of Home Health Aid - Yes	13%
Widowed	11%	PRISMA – 7, median (IQR)	1.5(2)
Other	2%	SPPB, median (IQR)	9(4)

- The IMU-vision system demonstrated good feasibility and high accuracy in activity recognition.
- 80% of the assessments were analyzable by the activity-recognition algorithm, which overall correctly identified 100% of walking, 97% of balance, and 82% of sit-to-stand activities ($\chi2(2)=19.9$, $p<0.001$) (**Figure 1**).
- The activity scoring module correctly scored 74% of assessments. Accuracy rates differed across activity types ($\chi2(2) = 14.9$, $p < 0.001$); 87% of balance, 50% of sit-to-stand tests, and 66% of walking received identical manual and automated scores (**Figure 2**).

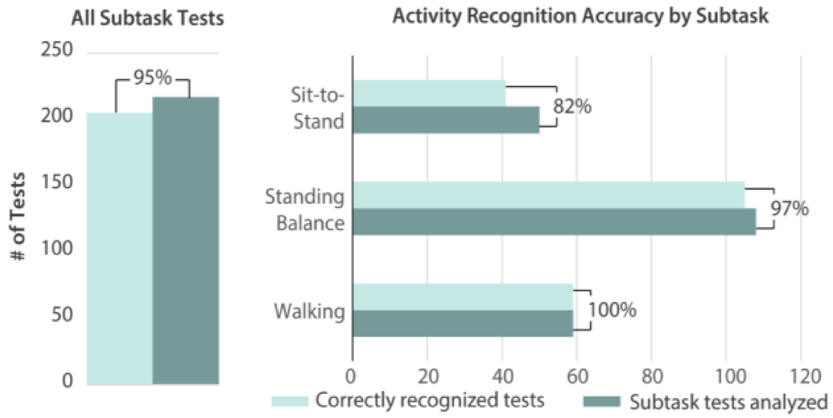


Figure 1

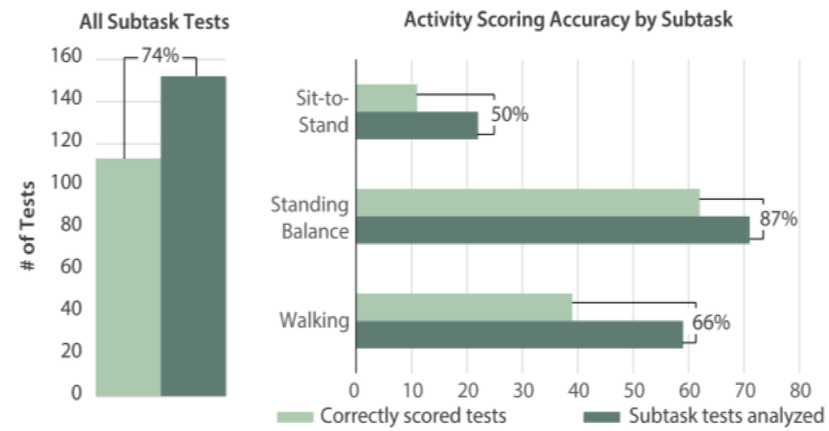


Figure 2

CONCLUSION

- An IMU-vision system that blends multimodal sensing, activity recognition, and movement assessment algorithms can satisfactorily identify in-home function, although system robustness can be further improved.
- This system has a significant opportunity to improve the assessment and subsequent monitoring of patients at home in the future.
- Home Hospital care becomes proactive as a result, ensuring that patients get the proper degree of care and assistance at the precise time that is most needed.