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Classifying Patient Handling Techniques to Reduce Risk of Musculoskeletal Injury in Nursing Students

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Introduction

Studies show that musculoskeletal injuries among registered nurses occur at a rate of 28.9 cases per 10,000 workers; this injury rate is double that of all other occupations [1]. The purpose of this study is to use OpenCap, a video software which captures whole-body kinematics data, in tandem with the XCM [2], MiniRocket [3], and ResNet [4] multivariate time series classifiers to accurately predict patient handling tasks and quality of posture (good, neutral, and poor) during these tasks, with three manikins of varying weights (44lbs, 66lbs, 110lbs) serving as patients. We expect that these findings will facilitate prevention of future injuries to nurses. Multivariate time series classifiers make classification predictions from numeric sequences of data over a period of time. Time series classification problems are either univariate (concerning a single feature) or multivariate (concerning several features). Our data is multivariate.

Methodology

We collected data from five able-bodied college students between the ages of 18 to 24; they stood with their backs to 4 OpenCap-enabled cameras (see figs 1 and 2) such that their whole bodies were framed within each camera. The six tasks performed were: rolling a patient to their side, sitting a patient up from a supine position, lifting a patient out of a wheelchair, lifting a patient's leg, sliding a patient up and down with a sheet, and rolling a patient onto either side in turn to place a sheet under them. Subjects performed 18 trials for each task; trials for all tasks except the wheelchair task were evenly divided into subsets of "good," "neutral," and "poor" posture.



Figure 1: Researcher performing the two-roll task with the help of another researcher in view of the cameras

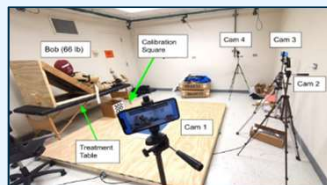


Figure 2: Lab setup

This was done by changing the treatment table height on which the manikin rested. Hip-height signifies good posture, mid-thigh height neutral posture, and knee height poor posture. Each trial consisted of 3 repetitions; repetitions were split by knee flexion markers and resampled to 100 time steps each. This study utilized a 60/20/20 train-validation-test split to test the accuracy of the models; manikin weights were added as dimensions in the time series data files to account for varying strain on the back and lower extremities. Datasets were normalized by subject height. Data collected from Subject 5 was excluded from the final results due to extreme noise and OpenCap glitching.

Results

MiniRocket proved to be the most accurate classifier (see figs 3 and 4). It was the only model to enjoy a marked benefit in classification accuracy when input data was normalized by each

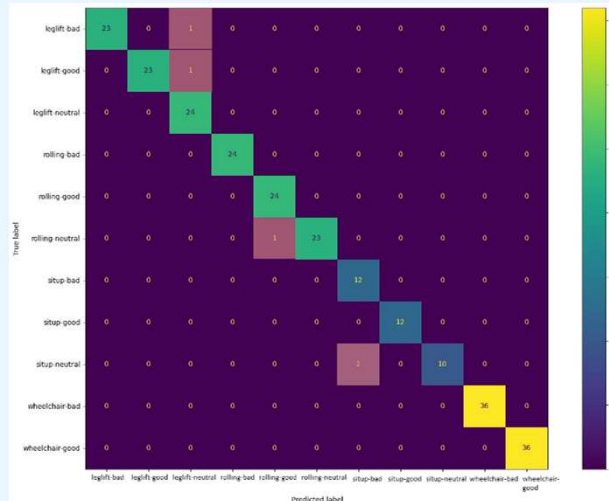


Figure 3: MiniRocket confusion matrix over a single iteration using features XCM deemed as important

respective subject's height and manikin weights were included as a time series feature. This could be due in part to an insufficient range in manikin weights making it difficult for ResNet and XCM to discern noticeable changes in posture quality across all tasks. MiniRocket predicted the correct task and quality of posture 96.2% of the time; neither XCM or ResNet reached 95% classification prediction accuracy.

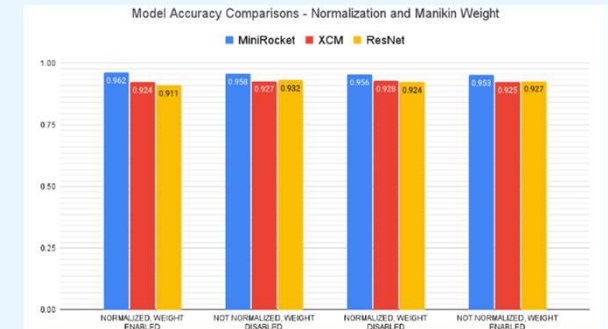


Figure 4: Classifier accuracy comparison chart with and without data normalization and manikin weight inclusion as a time series feature (using features XCM deemed important)

Conclusion

This served as a proof of concept. Our findings demonstrate that the MiniRocket classifier produced more accurate classification predictions across six patient-handling tasks than ResNet and XCM. Manikin weight as a time series feature and dataset normalization by subject height had a positive impact on MiniRocket's accuracy, but had minimal or no impact on the other classifiers.

Future Work

Future research will employ nursing students with varying levels of experience in a similar study, in a simulated hospital environment to make research results more generalizable and expedite the design of a tool that provides feedback to nurses regarding their posture during patient-care tasks to prevent injuries.

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