Perception of Sleeping Poses Using Extremity Limb Orientations

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Introduction

A study revealed a positive correlation between prolonged joint immobilisation and muscular contractions [1], raising concerns over body poses during sleep. For instance, many lower limb conditions stem from *gastrocnemius contracture*, a tightness of the calf muscle impairing the ankle joint. Motivated by this anecdotal evidence, tracking in-bed body poses would provide valuable information for clinicians to verify the link between sleeping poses and musculoskeletal pathologies in the long term, thus justifying the most appropriate preventive clinical interventions. The majority of published works on static body pose classification is dominated by non-wearable technologies, such as pressure-sensitive mattresses [2] and infrared vision [3]; however, these suffer from occlusions. Meanwhile, wearable-based approaches are still in a premature stage and often consider only four standard poses [4].

Methods

The feasibility of classifying a larger number of sleeping poses by solely using inertial cues was investigated. The proposed approach emulates in-bed body poses using a virtual character 3D model. Leveraging on *Blender*©, a computer graphics software, the model was rigged up with a full-body skeleton providing a framework for model pose adjustment. Eventually, an animation containing the 12 unique typical sleeping poses shown in Figure 1 was created. The kinematic representation of all body segments is then exported to a standard file format commonly used by wearable inertial sensors; however, only the four extremity joints (wrists and ankles) are considered in this case study. To overcome the scarcity of labelled inertial data, a novel data augmentation technique is proposed to generate synthetic datasets under realistic conditions such as intrinsic sensor noise. With the enhanced dataset, an Error-Correcting Output Codes model based on Support Vector Machine classifiers is trained to recognise the underlying sleeping pose.

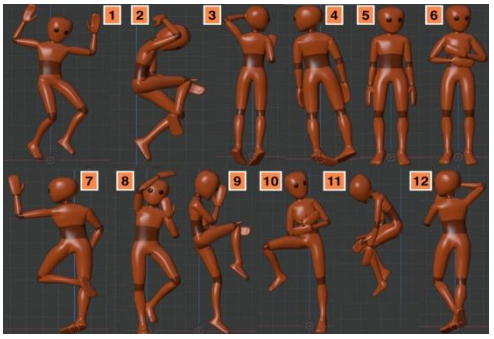

Figure 1. Rigged Skeleton.

Results & Discussion

To evaluate the proposed approach, 24 augmented datasets were generated with different noise levels in the orientation of extremity limbs. Experiments showed classification accuracies as high as 100%, and resilience to noise contamination beyond what is encountered in modern off-the-shelf inertial sensors. Despite the axes and angles of rotation of extremity limbs being corrupted with noise deviations up to ± 25.7° and ± 18.2° respectively, the system accuracy remained well above 75%.

Conclusions

The case study presents a proof-of-concept that a large number of sleeping poses can be recognised using the extremity limb orientations from inertial observations. Promising results show the high robustness of the proposed approach to noisy orientation measurements, owing to the novel proposed data augmentation technique.

References

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