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Inertial Sensing Simulations Using Modified Motion Capture Data

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Introduction

Simulators of Body Sensor Networks (BSN) constitute an important part of technical development and hypothesis testing. Being able to repeatedly perform a motion exactly to trial different sensor placements may be difficult using real subjects but could greatly be aided by these tools [1-2]. Motion capture data can also be modified using inverse kinematics (IK)[3-5]. However, simulating inertial sensing output from modified motion sequences has yet to be explored.

Overview of approach

This work introduces modifications to motion capture using inverse kinematic methods and coupling this to multiple instances of simulated inertial measurement unit (IMU) sensors. A simulator was constructed to illustrate the concept, by combining a physics-enabled game engine[6], implementations of a IK solver[7] to modify capture data, and IMUSim to simulate the sensor output (Fig. 1).

Step 1: IMU simulation

The original motion data is used to simulate IMU signals with nine degrees of freedom (9DOF) from a given joint or surface on the virtual subject.

Step 2: Modification

Modification of the motion capture is done by combining the joint movements with an inverse kinematics solver in a physics-enabled game engine. Environmental interaction and injury (e.g. joint constraints, displacement) are some of the possible scenarios that can be simulated.

Step 3: Modified IMU simulation

The modified motion capture is used as input for IMU simulation. Original and altered data under different scenarios can thereafter be compared.

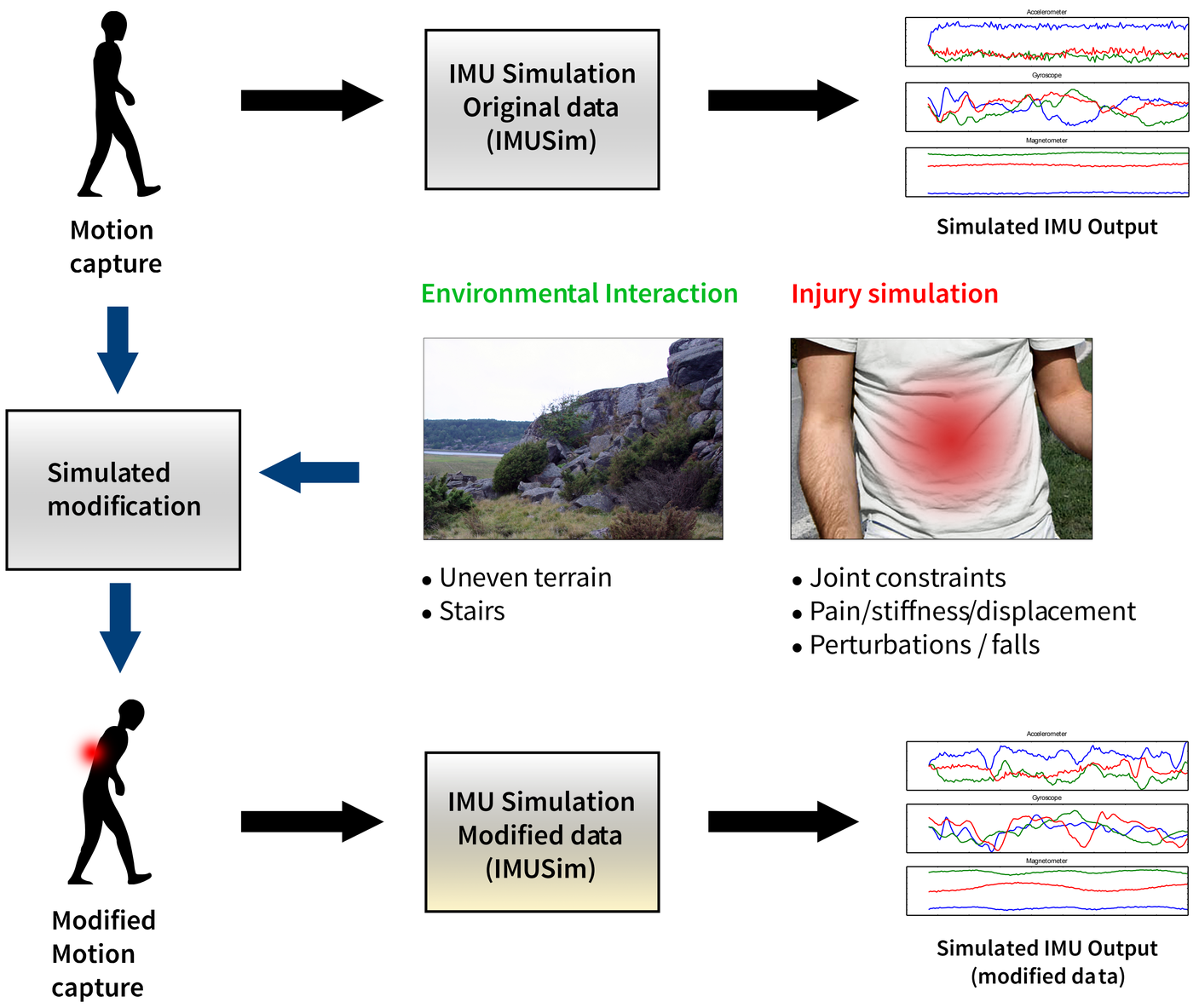

Figure 1. Overview of approach. Interactive web version available at **http://www.doc.ic.ac.uk/~pjk113/**.

Environmental interaction and injury simulation

The simulator was used to generate multi-sensor output from motion capture of different body parts under normal and abnormal conditions. Using data from the Carneige Mellon University (CMU) Motion Capture Database[8], simulations from the original data (Fig. 2a) is compared to modifications such as a simulated truncal injury through a stiffened spine and displaced upper body (Fig. 2b) an uneven surface (Fig. 2c) and an incline (Fig 2d).

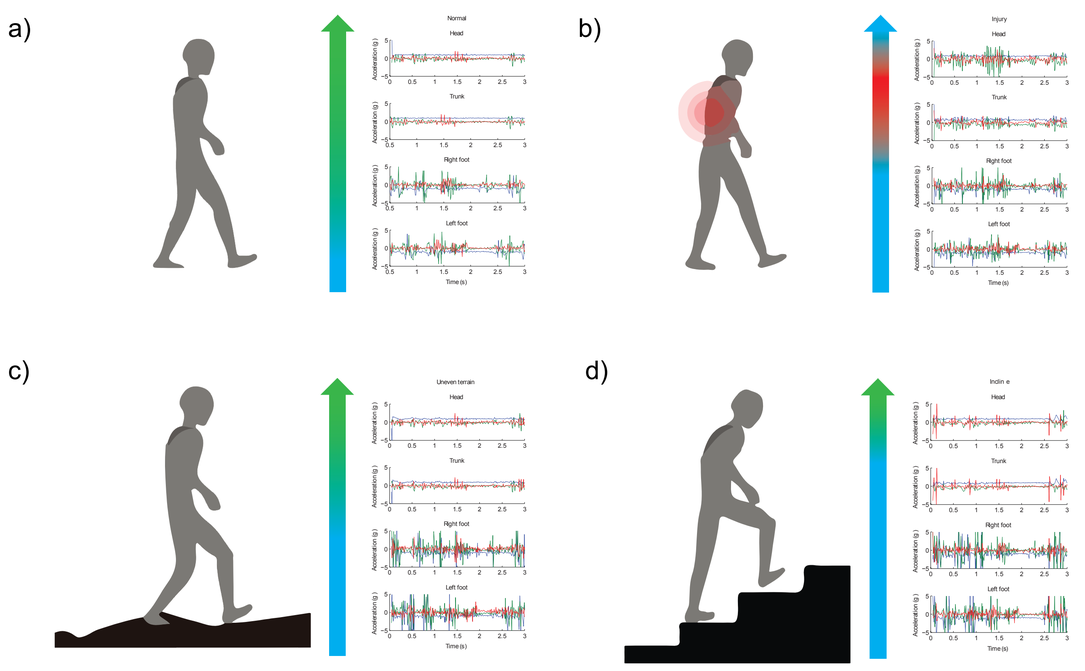

Figure 2. Data from the CMU Motion Capture Database[8] was used to simulate multi-sensor output in four different scenarios by IK modification. The figure shows a comparison between (a) the original dataset, (b) simulated truncal injury (stiff spine and displaced upper body), (c) an incline, and uneven surface(d). Three-axis accelerometer as X (blue), Y (green) and Z (red) – gyroscope and magnetometer output not shown. Coloured arrows give a qualitative indication of relative dampening (normal, uneven, incline) and level of displacement for simulated injury.

Conclusions and further work

This work represents an extension of existing BSN simulators. It could be used in biomotion sensing investigations for the generation of anomaly training datasets from individualised motion data. Our initial findings will be investigated through validation and comparison to real scenario data. We will also use the simulator to guide wearable sensor development for animals.

Acknowledgements

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Interactive Simulator Available (PC/Mac)

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