Tracking Bilateral Lower Limb Kinematics of Distance Runners on Treadmill using a Single Inertial Measurement Unit

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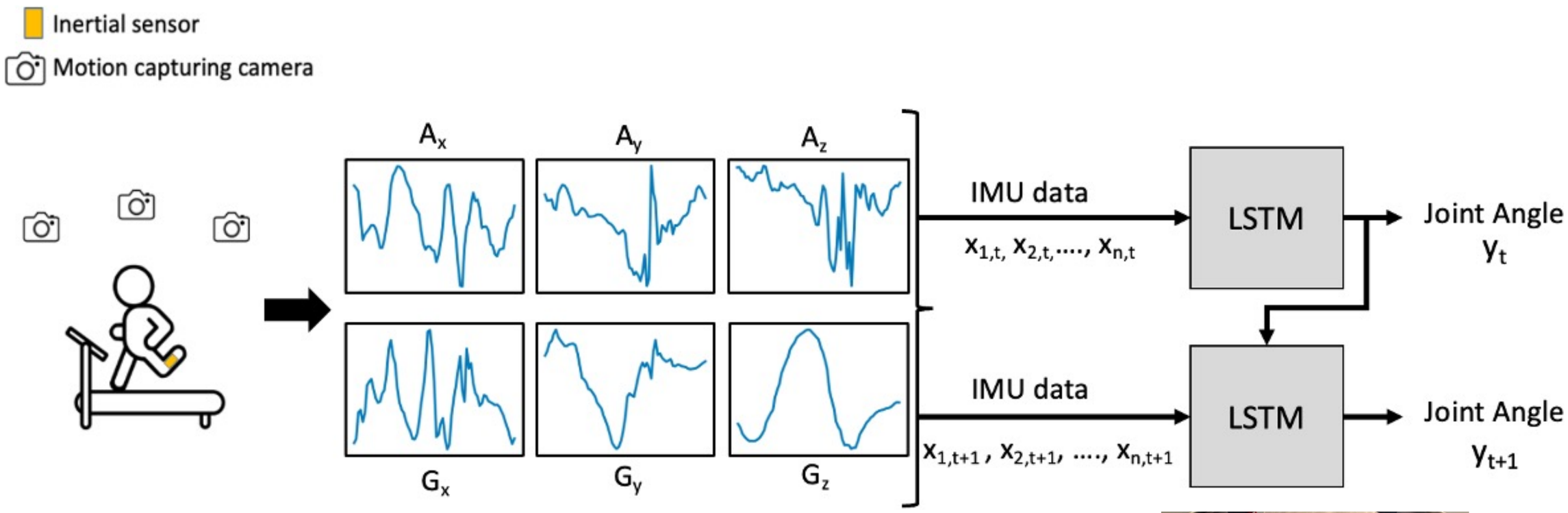
Background

- 79% regular runners experience injuries annually.
- Detecting faulty running kinematics is important to gait retraining as a potential solution for injury reduction.
- **Limitations of traditional kinematics measurement**: Motion capture (MoCap) systems are costly, cumbersome, and impractical for widespread use.
- **Objective**: Developing a wearable solution to accurately estimate lower limb running kinematics using a single inertial measurement unit (IMU) placed on the left lower leg.

Figure 1. Motion Capture System setup with 25 markers worn by the subject and 5 cameras in the room measuring ground-truth lower limb kinematics https://www.thebiomechanicslab.com.au/how-we-use-3d-gait-analysis-treatment/

Methodology



- IMU and MoCap data was collected and provided by School of Health Sciences, Western Sydney University.
- 20 healthy recreational runners (10 male and 10 female participants) were recruited for this study.
- This study used OPAL IMU sensors and Vicon Cue Video Cameras.
- Participants ran at speeds of 9, 10, 11 and 12 km/h for data collection.
- An LSTM neural network was trained with 6 input features from IMU to predict lower limb joint angles.
- The model was evaluated using RMSE (root mean squared error).

Figure 2. B. Fuller, "Prediction of lower limb kinematics during treadmill running by a single inertial sensor," M.S. Thesis, School of Health Sciences, Western Sydney University, Sydney, 2023, Figure 2, "Static participant posture standing over marker." (accessed Apr. 4, 2023)

Results and Application

- ❖ The model predicted joint angles with an RMSE ranging from 3° to 28° using a single IMU.
- ❖ This solution can be used as a monitoring device to track essential running kinematics in natural running environments.
- ❖ It can become an integral part of real-time gait retraining biofeedback systems for injury prevention and rehabilitation.
- ❖ Performance enhancement with remote monitoring is also an interesting application of this solution.

	RMSE(°)	
Joint Angle	Ipsilateral limb	Contralateral limb
Sagittal Hip	17.065	19.123
Frontal Hip	3.492	4.019
Transverse Hip	4.324	4.465
Sagittal Knee	27.118	27.508
Sagittal Ankle	16.942	16.873
Frontal Ankle	6.268	5.809

Y. Patra, Q. Liu, R. H. M. Chan, D. Thomson, D. H. K. Chow, B. Fuller, and R. T. H. Cheung, "Tracking Bilateral Lower Limb Kinematics of Distance Runners on Treadmill Using a Single Inertial Measurement Unit," in Proceedings of the 45th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), Sydney, Australia, Jul. 2023 (accepted).