Development of a rider posture estimation system

Ioannis Symeonidis, Stella Nikolaou, Evangelos Bekiaris

I. INTRODUCTION

Rider upper-body posture can vary significantly during motorcycle riding [1] as the rider is actively involved in controlling the motorcycle and is not restrained as in a car. The rider's posture can influence the outcome of an accident [1]. It is important for the activation of automated motorcycle functions as autonomous braking [2] and can be used for the detection of distractions [3]. For the estimation of the rider's posture, a wearable system with sensors was developed that can be integrated into the rider's PPE.

II. METHODS

The sensors used were Inertial Measurement Units (IMU) MEMS (microelectromechanical systems), which can be integrated into the rider's PPE with minimal influence on its effectiveness. The selected IMU integrate three-axis accelerometer, gyroscope and magnetometer. Three IMUS were rigidly attached to the motorcycle, to the rider's back and to the helmet and connected to a controller that performed the posture estimation calculation.

Posture estimation

The IMUs' sensors cannot directly measure the position of the motorcycle and rider's body regions for the posture estimation because they are measuring linear acceleration and angular rate, respectively. For this reason, a combination of two methods was used to estimate the rider's position.

As a first step, after filtering the signals, a complementary filter was used for both sensors to estimate the orientation of the IMUs. The roll and pitch angle of the IMUs is calculated from both sensors. For the gyroscope signal, an integration was performed for this purpose while trigonometry and the components of the gravity vector distributed to the accelerometer axes were used for the calculation of the angles from the accelerometer. A complementary low pass filter was used for the accelerometer and a high pass for the gyroscope, and then they were both used for a more accurate estimate of the angles. For the pitch and roll angle representation, Euler angles were used with specific axis orientation to avoid cardan lock.

For the rider's posture, the position of the body regions relative to the motorcycle orientation was estimated considering rigid links between the IMUs and using the previously calculated orientation angles. For this purpose, the Denavit Hartenberg (DH) convention was used for the matrix representation of the problem and the forward kinematics calculation was performed for the estimation of the IMUs' position.

III. INITIAL FINDINGS

The algorithm was developed and evaluated using a 3-link model of the rider with the IMUs attached in known positions on the links, allowing the angles to be measured easily. Additionally, a measurement with an upright motorcycle was performed for the estimation of the angles by attaching the IMUs to the motorcycle and the rider's body. The rider leaned the motorcycle and changed his posture. In Fig. 1, the signals from the helmet IMU and the Euler angle calculation for the helmet are presented.

I. Symeonidis, S. Nikolaou and E. Bekiaris are researchers in the Centre for Research and Technology Hellas in the Hellenic Institute for Transport. I. Symeonidis is also an external doctoral student at the Ludwig Maximilians University, Munich, Germany.

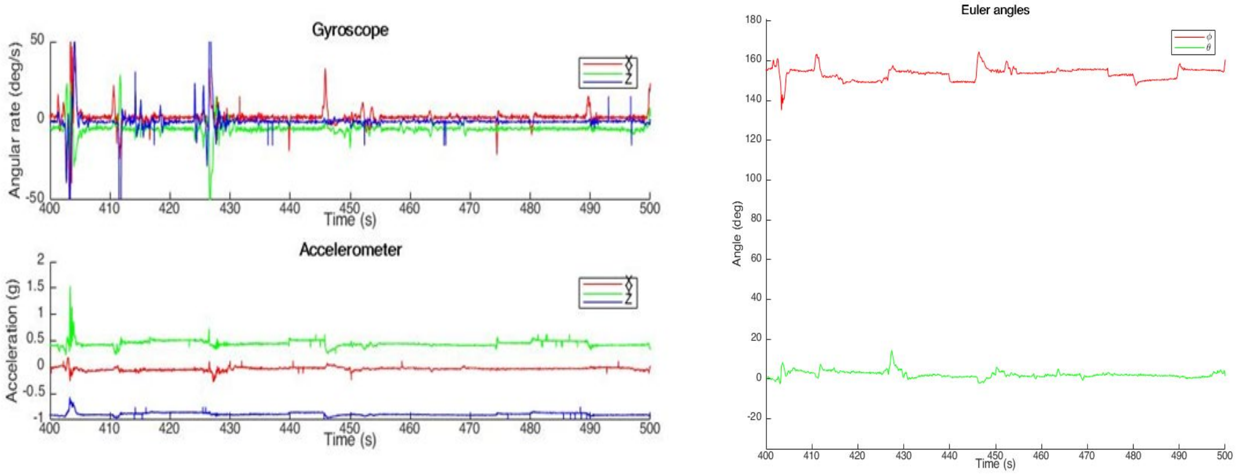

Fig. 1. Accelerometer and Gyroscope filtered signals and orientation angle estimation for pitch and roll of the helmet.

IV. DISCUSSION

The calculation of the orientation angles and the estimation of the rider’s posture produces useful signals that can be employed in various ADAS for motorcycles as a distraction monitor, fatigue warning system and rider intention prediction, among others. One of the algorithm’s limitations is that the influence of the yaw angle is not taken into account with this approach because the accelerometer cannot be used as the rotation is around vertical axis and only the integration of the gyroscope signal produces significant drift. Further developments and evaluation of this approach will be conducted via lab experiments with a state-of-the-art motion-capture system and also with motorcycle riding in real-world conditions to improve the system.

V. ACKNOWLEDGEMENTS

This work was partially funded from the EU Horizon 2020 research program ADAS&ME (Adaptive ADAS to support incapacitated drivers & Mitigate Effectively risks through tailormade HMI under automation).

VI. REFERENCES

[1] Symeonidis, I., *et al*., *IRCOBI*, 2018.
[2] Merkel, N. L., *et al*., IfZ conference, 2020.
[3] Symeonidis, I., *et al*., IfZ conference, 2018.