Popular science summary
Classifying Motion Patterns of Bikes using Machine Learning

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In an effort to improve theft detection alarms for electrical bikes, machine learning models were investigated to find out if motion patterns can be classified accurately. A final accuracy of 94.65% was achieved.

Electric bikes have become a common sight in traffic, and with a growing user base and expensive prices, a demand for bike protection is increasing. Imagine that someone steals your bike, without proper protection you will likely never see it again. If your bike had the capability to recognize that it is getting lifted or rolled away while it is locked, it could trigger a deterring alarm which notifies you and everyone around, and potentially scares away the thief. Another way to protect your expensive bike would be to notify you if the bike has fallen over and is laying on the ground where it risks damages from its surroundings, so that you can put it back up to a safe position again. With effective motion recognition, solutions to scenarios like these can be developed.

Different types of machine learning model were tested, which included a $k-$nearest neighbour classifier and two types of neural networks. Machine learning models use mathematical computations to find patterns in data. The patterns are then used to find the difference between the classes. The best performing model was a neural network which combined the two different types of networks into a single network. It was able to correctly classify the motion patterns with an accuracy of 93.96%. Applying a filter on the output reduced the amount of wrong classifications slightly and increased the accuracy to 94.65%.

When testing the model on other bikes, not used previously in development, it was quickly realized that it did not perform as well on those bikes. The accuracy dropped to about 35%, which indicates that further improvements are needed.

The classification was based on data from an accelerometer, a gyroscope and a magnetometer. In an effort to make the solution applicable in real-time, the data got stored into time windows. The models tried to differentiate the data within the windows and learn what data from the different motion classes looked like. There was six different motion patterns the models tried to classify and they were; *Stationary*, *Falling over*, *Lifted*, *Rolling*, *Shaken* and *Picked up from the ground*.

Machine learning methods are often complicated and it is often hard to understand how they come up with their decisions. A method called Grad-CAM was used to try and highlight what parts of the input the models found to be the most important. From the created images, it was understood that the gyroscope values had a large impact on the model's decision making.

The results indicates that the current solution is not accurate and adaptive enough to perform in a real scenario. However the current solution looks promising if the suggested improvements are implemented.