# Popular Science Summary of the Master Thesis Report ”Slip Control for a Three-Wheeled Electric Motorcycle”

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**Global warming is forcing car manufacturers to develop electric vehicles for the future. This can make a real engine aficionado a bit concerned when roaring combustion engines go extinct. However by going electric does not mean the vehicles needs to be boring, with the almost instant torque response and fast acceleration the driving experience an electric vehicle provides can be very exciting.**

Electric vehicles are becoming more and more common on the roads. This means that all the safety features that are found in vehicles with an internal combustion engine need to be developed for the electric vehicles too. Among these safety features, traction control to some extent is very common, i.e., a mechanism that prevents the driver to lose control over the vehicle because of hard braking or acceleration, slippery surfaces or fast movements on the steering wheel. Electrification introduces new possibilities but also new challenges, e.g., regenerative braking, i.e., letting the motor act as a generator during braking and by doing so recovering some of the kinetic energy.

Today it is not only the automotive and the transport sectors that are being electrified, but also recreational vehicles. One such vehicle is the OMotion 2, a three-wheeled electric motorcycle developed by OMotion AB, see Fig. 1. It consists of two wheels at the front and one at the rear; the electric motor is mounted on the rear wheel and provides both driving torque and braking torque during regenerative braking. During hard acceleration and regenerative braking the rear wheel tends to spin and lock-up, respectively. This may cause instability of the vehicle and the driver may lose control over the vehicle.

Fig. 1. **The OMotion 2.**

One way to accommodate this problem is to introduce a slip controller, i.e., a control system that prevents the rear wheel to spin and lock-up during acceleration and regenerative braking, respectively. This can be done by controlling the slip of the rear wheel, i.e., the difference between the longitudinal velocity and the velocity of the driving wheel. Control of the slip can be accomplished by measuring the velocity of the vehicle itself and the rear wheel velocity. From these measurements, the slip ratio can be estimated for the acceleration and the regenerative braking phases. The goals of the Master's Thesis [1] were to compare three different control structures for slip control through simulations as well as to design and implement a slip controller on the OMotion 2.

The velocities of the vehicle and the rear wheel were measured with Hall sensors on each wheel. Since it is only the rear wheel that is driving, the velocity of the vehicle was estimated by the measurements from the two front wheels. Two gain-scheduled Proportional Integral (PI) controllers were designed and implemented on the OMotion 2, one for the acceleration case and one for the regenerative braking case. The slip controller was tested and evaluated in different experiments on a road with a slippery surface. The experiments were performed along a straight line from standing still to full acceleration and from a high speed to full stop for the acceleration case and braking case, respectively.

The slip controller performed well in the experiments in the sense that the driving experience felt much safer and controlled on slippery surfaces, compared to without a controller to assist the driver where the driving experienced felt unsafe and it was hard to keep the vehicle under control. There are more testing left to be done for different driving conditions, e.g., how the controller performs during cornering but also when disturbances such as the hydraulics brakes are used in combination with the slip controller.

## References

[1] Karlin, Andreas (2021). ”Slip Control for a Three-Wheeled Electric Motorcycle”. Master's Thesis TFRT-6128. Lund, Sweden: Department of Automatic Control, Lund University, Lund, Sweden, 2021. Available for download from https://lup.lub.lu.se/student- papers/search