**Autonomous Drifting and Stability Control Research Proposal**

**Research Objective The goal of this research is twofold:**

* **Autonomous drifting implementation** – developing an algorithm that can control a vehicle in a continuously unstable state.
* **Stabilization application** – using the knowledge gained from autonomous drifting to help a vehicle regain stability in real-world scenarios, such as hydroplaning on highways or sudden loss of traction at high speeds.

Research Plan

1. Sensor Selection and Data Acquisition To achieve precise vehicle control in extreme conditions, the following sensors will be used:

* Camera – detects the road and track layout.
* LIDAR – provides depth perception, useful for recognizing track edges and obstacles.
* IMU (Inertial Measurement Unit: accelerometer + gyroscope) – measures angular velocity, tilt, and drift.

1. Algorithm Development The objective is to create a control algorithm that maintains the vehicle in an unstable yet controlled drift. Possible approaches:

* **Classical control methods (PID, MPC)** – initial experiments could use PID control, followed by Model Predictive Control (MPC) for more advanced optimization.
* **Machine Learning (Reinforcement Learning – RL)** – training an RL model to drift autonomously through trial-and-error learning.

1. Drifting Mechanics and Control Drifting relies on oversteering and counter-steering techniques. The algorithm must control:

* Throttle and braking optimization.
* Individual wheel braking.
* Steering angle adjustments.
* Rear-wheel slip control.
* Electronically locking differentials.

**Drifting Techniques for Different Drive Types:**

* **Front-Wheel Drive (FWD) Drift:**
  + Modern vehicles are often front-wheel drive, making traditional drift techniques less effective.
  + The primary method for initiating a drift in FWD cars is the handbrake drift, where the rear wheels are locked momentarily while steering into a turn.
  + Throttle control is used to maintain the drift angle.
  + Momentum drifting techniques may be required due to the nature of power distribution in FWD vehicles.
* **All-Wheel Drive (AWD) Drift:**
  + AWD vehicles provide power to all wheels, requiring a combination of techniques.
  + A power-over drift can be utilized by applying excessive throttle to induce oversteer.
  + Left-foot braking and adjusting torque split dynamically can enhance control.
  + Electronically controlled torque vectoring can optimize AWD drift stability.
* **Rear-Wheel Drive (RWD) Drift:**
  + Traditional drifting techniques work best in RWD vehicles.
  + Methods include clutch kick drift, power-over drift, and brake-induced drift.
  + Rear-wheel slip control is key to maintaining controlled instability.

1. **Stability Control Research**: Once the drifting algorithm is functional, the next step is to investigate how the collected data can be used for stability recovery in real-world situations. The system would:

* Detect loss of control (using IMU, LIDAR, and camera data).
* Automatically intervene (adjust steering, throttle, and braking).
* React faster than a human driver to prevent accidents.

1. Simulation and Testing

* BeamNG.drive simulation will be used for initial development and testing.

**Additional Considerations**

* Modeling vehicle physics – incorporating mass distribution, traction, and suspension effects.
* Adaptive control – allowing the system to adjust for environmental conditions (e.g., dry vs. wet roads).
* Machine learning enhancement – reinforcement learning may provide better real-time control optimization.

**The purpose of this research:**

The objective of this research is to document and publish the findings from my experiments, contributing valuable insights to the future development of automotive technology.

**Planned Attribution**

I intend to properly cite and acknowledge BeamNG in my publications and research materials. Additionally, I will include the BeamNG logo in relevant presentations and documents to highlight its contribution to my work.

**Final Goal and Practical Applications**: If successful, this research could be applied to:

* Emergency vehicle control and crash prevention systems.
* Automatic stabilization in high-performance racing vehicles.
* Highway safety systems to counteract hydroplaning or sudden traction loss.

**Conclusion:**

This research aims to push the boundaries of autonomous vehicle control by integrating extreme motion dynamics (drifting) with real-world stabilization applications. By considering different drivetrain configurations (FWD, AWD, RWD), this study seeks to develop adaptable algorithms that can enhance both high-performance driving and safety applications. With a detailed research plan and access to BeamNG.tech, this study could lead to innovative breakthroughs in vehicle safety and performance.