Safety ForceField Verification

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Background

More than a millon people are killed in vehicle collisions each year worldwide [1]. Active safety systems like NVIDIA's Safety Force Field (SFF) could use field gradient control to intervene and save many of these lives.

Before allowing autonomous software to override human control, though, we need strong guarantees on the software's safety and correctness.

SFF is provably safe with some assumption, but real-world robustness must be quantified [2]. Further, false positives reduce the safety system's usefulness and need to be measured.

Methods

I developed two tools to help verify safety force field's behavior.
First: I added a graphical interface for investigating SFF's behavior under different scenario and vehicle parameters. This interface could be used to help recreate and debug SFF's behavior.

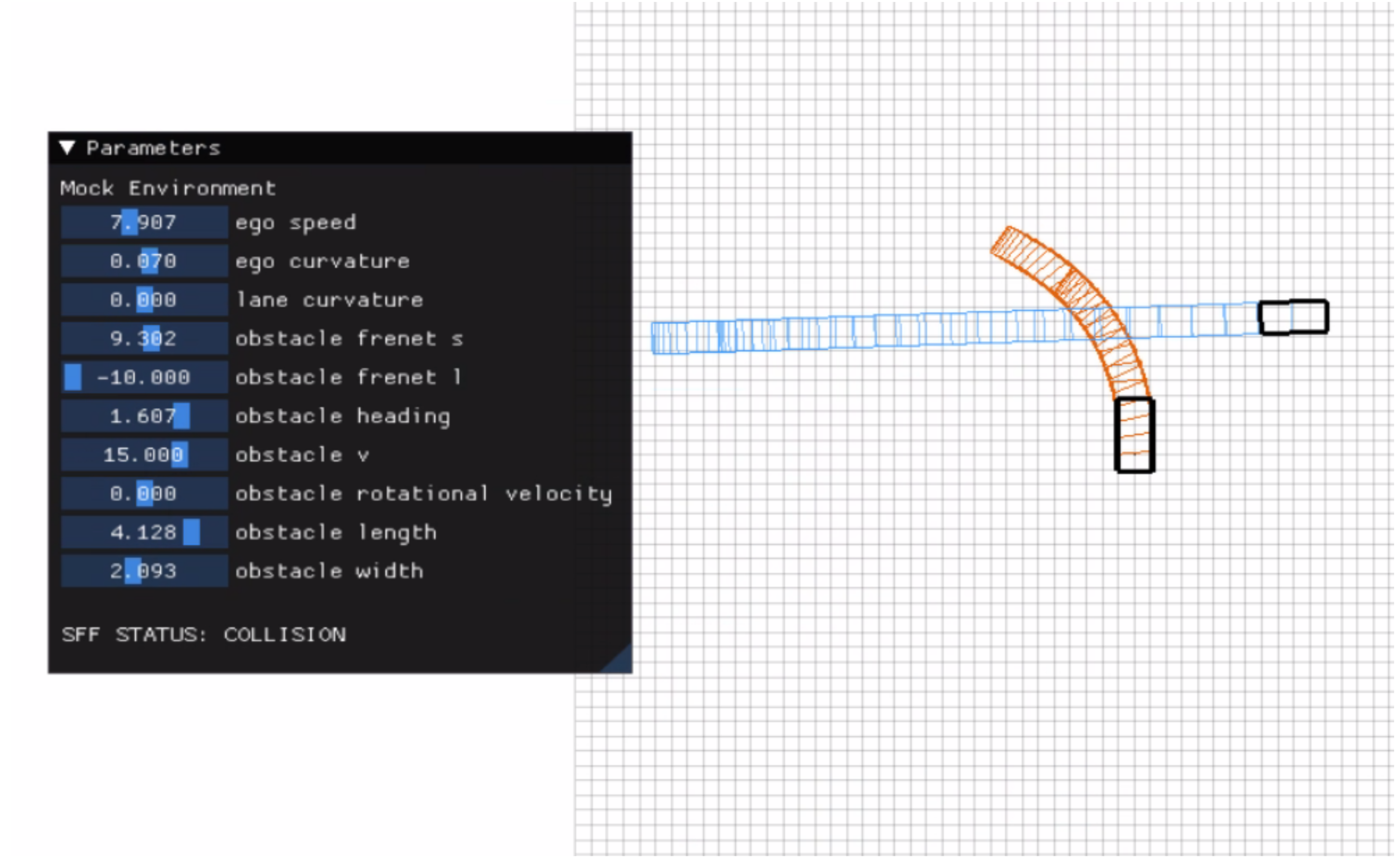

Figure 2: Safety Force Field Scenario GUI

Second: I added support to check accurately detect collisions and false positives inside the SFF sample app. This app support writing test cases to for catching bugs and regressions.

Time of Event	Event
SFF detect collision and triggers	Wait for *Forward Tolerance* seconds
SFF triggers + *Forward Tolerance*	Start the Safety Procedure
All actors come to stop on first run	Reset the simulation state to SFF triggers + *Forward Tolerance* - *Reverse Tolerance* and start the Safety Procedure again.
All actors come to stop on second run	Analyze runs for false positives

Table 1: Timeline for False Positive Checking

Results

Using these apps, we were able to profile SFF's tolerance under a greater variety of vehicle models and on different road scenarios.
The metric we used is *Forward Tolerance* and *Reverse Tolerance* for the margins required to avoid false positives and false negatives respectively.

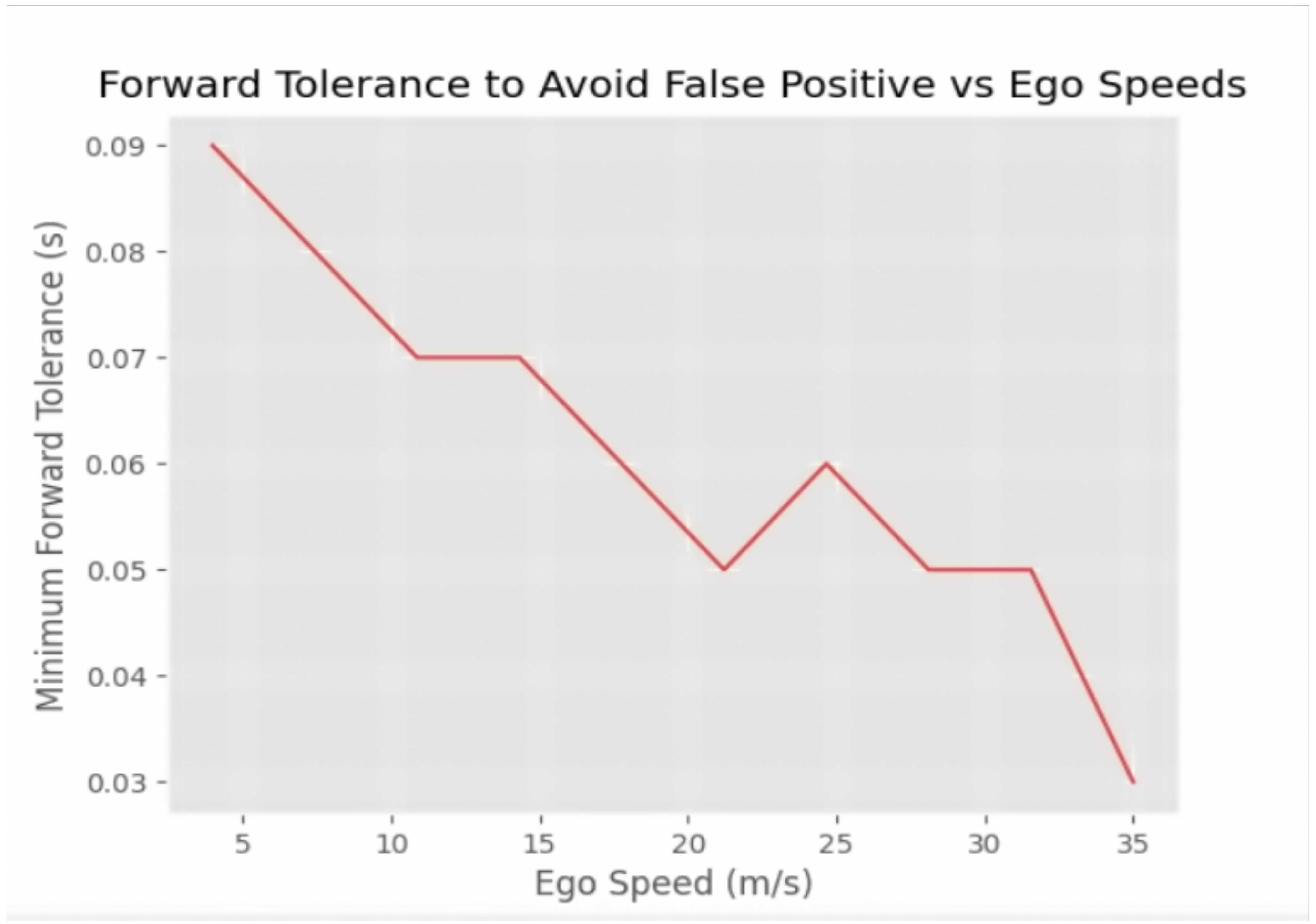

Figure 1: Safety Force Field Scenario GUI

Conclusion

This verification work is a good start to guaranteeing SFF's safety across diverse road scenarios and vehicle models. Future work will extend this verification to run DriveSIM where even more complex and higher fidelity vehicle models can be tested.
Identifying which parameters safety force field is most sensitive to is important, so sweeping a greater variety of models and parameters and perhaps quantifying a robustness to each could also be valuable work in the future.
Finally, this verification work may help lay some groundwork for Automotive Safety Integrity Level certification of the Safety Force Field module.

References

[1] Global status report on road safety, 2018.

[2] David Nistér, Hon-Leung Lee, Julia Ng, and Yizhou Wang. The safety force field. Technical report, 2019.