Demo: Disclosing the Pringles Syndrome in Tesla FSD Vehicles

Zhisheng Hu, Shengjian Guo, Kang Li
Baidu Security
zhishenghu,sjguo,kangli01@baidu.com

***Abstract*—In this demo, we disclose a potential bug in the Tesla Full Self-Driving (FSD) software. A vulnerable FSD vehicle can be deterministically tricked to run a red light. Attackers can cause a victim vehicle to behave in such ways without tampering or interfering with any sensors or physically accessing the vehicle. We infer that such behavior is caused by Tesla FSD's decision system failing to take latest perception signals once it enters a specific mode. We call such problematic behavior *Pringles Syndrome*. Our study on multiple other autonomous driving implementations shows that this failed state update is a common failure pattern that specially needs attentions in autonomous driving software tests and developments.**

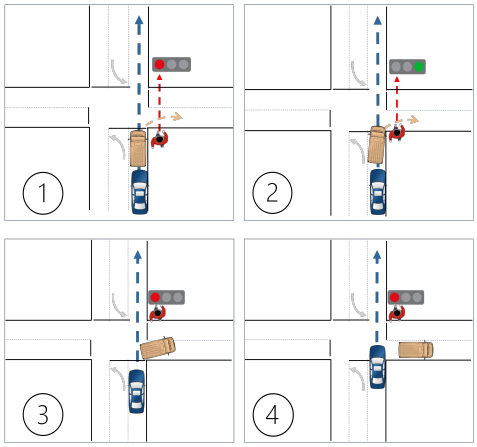

Fig. 1. Illustration of the attack scenario.

I. The Pringles Syndrom in an AI system

An autonomous driving system, such as Tesla FSD, includes multiple artificial intelligent modules. The decision module uses signals generated by various perception modules and makes trajectory planning and vehicle driving controls. We call an AI system presents a *Pringles Syndrome* [1] when the AI's decision module uses outdated information to command its action and ignoring all the latest perception updates.

[1]*Pringles Syndrome* refers to the behavior of "once started, cannot stop". It refers the FSD software's behavior that once the start-to-move decision is made, it can't get back to a wait state until the vehicle crosses the intersection".

Workshop on Automotive and Autonomous Vehicle Security (AutoSec) 2022
24 April 2022, San Diego, CA, USA
ISBN 1-891562-75-4
https://dx.doi.org/10.14722/autosec.2022.23019
www.ndss-symposium.org

II. Demo Overview

In this demo, we demonstrate how an attacker can leverage the *Pringles Syndrome* and cause a Tesla FSD deterministically run a red light.

The experiment was conducted on a public road without affecting other vehicles. We have tested different models of Tesla vehicles (e.g., Model 3 and Model Y) and at different time. They all presents the same problematic syndrome. As shown in Fig. 1, we list the experiment steps as follows. **(1). Basic setup**. The victim Tesla vehicle is enabled with the FSD functionality and runs in the FSD mode. The victim Tesla vehicle is set to run on a pre-selected route that passes an intersection with traffic lights. Another vehicle (let's call it *vehicle X*) runs in front of the Tesla FSD victim vehicle on the same lane. **(2). Fig. 1-①**. *vehicle X* and Tesla arrive at the intersection when the traffic light is red, and *vehicle X* is ahead of Tesla, planning to turn right. **(3). Fig. 1-②**. When the traffic light turns from red to green, *vehicle X* does not resume to move (due to reasons such as a pedestrian crossing the road) and thus blocks Tesla from moving forward. Consequently, Tesla is still in the stop mode waiting before the intersection. **(4). Fig. 1-③**.After the traffic light turns RED again, *vehicle X* starts to move (e.g., making a right turn). **(5). Fig. 1-④**.After *vehicle X* leaves, the victim Tesla then goes straight through the intersection even though the traffic light are in RED mode.

Fig. 2. Video screenshots of Tesla's FSD running through a red light.

Fig. 2 presents some screenshots of the demonstrated scenario. The attack was successful: Tesla FSD ran the red light even it was given enough time and distance to make the stop decision. We have successfully reproduced the behaviors on multiple different Tesla vehicle models, and we reported this problem to Tesla in November 2021. The video of a full experiment is available in https://youtu.be/cYC3qe2Pnj0.