From Mobile Sensing to Mobile Control of Vehicular Traffic

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In the last decade, rapid innovations in mobile computing have transformed how road traffic congestion is monitored. Traffic information systems reliant on dedicated, fixed sensing infrastructure have been significantly improved due to the pervasive sensing capabilities enabled by GPS equipped cell phones onboard a small fraction of vehicles in the traffic stream. These systems are now commercialized in numerous navigation services around the globe.

Following the paradigm shift to mobile sensing based traffic monitoring, it is now possible to consider if a similar advance can be achieved in traffic management using the vehicles as mobile actuators. Traffic control via mobile actuation is now viable thanks to recent and significant improvements in self-driving and connected vehicle technologies, and may offer new traffic management opportunities beyond today's fixed control systems such as variable speed limits.

As a motivating example, we show experimental evidence suggesting that careful control of a small number of autonomous vehicles in the traffic stream is sufficient to completely eliminate "phantom" traffic jams caused by human driving. We build on the seminal demonstration conducted by the *Mathematical Society of Traffic Flow,* in which 22 human-driven vehicles that initially drive smoothly around a circular track eventually degrade into substantial stop-and-go traffic. These experiments resolved a long-standing discussion in transportation science, namely that traffic waves can in fact arise without any external causes, but did not offer a solution to prevent it.

We repeat the 22 vehicle experiments with the modification that one intelligently controlled autonomous vehicle replaces a single human-piloted vehicle. A series of experiments in Tucson, Arizona are conducted to measure the influence of the carefully controlled AV on human-piloted vehicles. Our main experimental result indicates that even when the penetration rate of autonomous vehicles is as low as 5%, stop and go traffic can be eliminated. The elimination of waves allows significant improvements in the total traffic fuel efficiency and safety, and is achievable long before the majority of vehicles are automated.