Planning for Autonomous Cars that Leverage Effects on Human Actions

Dorsa Sadigh
Shankar Sastry
Sanjit Seshia
Anca Dragan

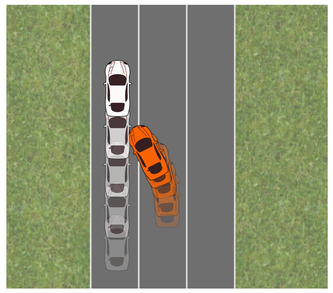
Make Someone Slow Down

Make Someone Change Lane

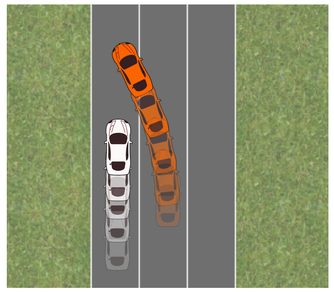
An autonomous car's actions will *affect* the actions of other drivers.

Coordinate to Cross First

Make Someone Speed Up



Plan conservatively and merge behind; Assuming human is a ***moving obstacle****.*



Car merges ahead of human; anticipates human ***braking****.*

Maximize Robot Expected Utility

$$\boldsymbol{u}_R^* = \underset{\boldsymbol{u}_R}{\operatorname{argmax}}\ R_R(x_0, \boldsymbol{u}_R, \boldsymbol{u}_H^*(x_0, \boldsymbol{u}_R))$$

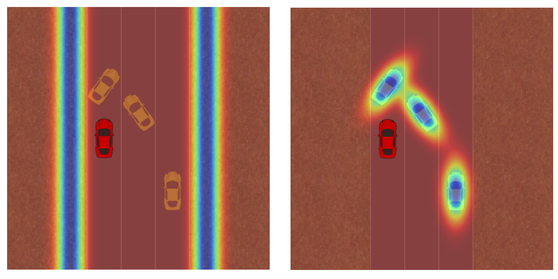
Find optimal actions for the autonomous vehicle while accounting for the human response $\boldsymbol{u}_H^*$.

Model $\boldsymbol{u}_H^*$ as optimizing the human reward function R_H.

$$\boldsymbol{u}_H^*(x_0, \boldsymbol{u}_R) \approx \underset{\boldsymbol{u}_H}{\operatorname{argmax}}\, R_H(x_0, \boldsymbol{u}_R, \boldsymbol{u}_H)$$

Learning Driver Models

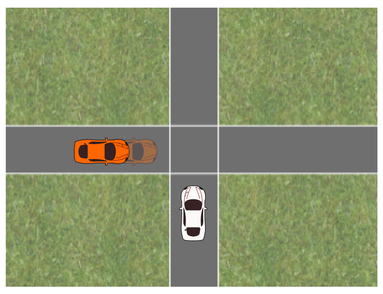
$$r_H(x^t, u_R^t, u_H^t) = w^\top \phi(x^t, u_R^t, u_H^t)$$



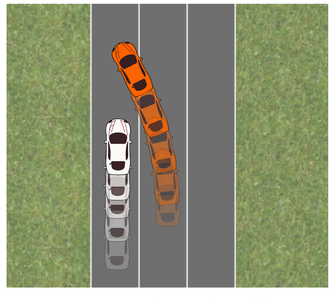
Assume human is noisily optimal:

$$\max P(\boldsymbol{u}_H | x_0, w) \propto \exp(R_H(x_0, \boldsymbol{u}_R, \boldsymbol{u}_H))$$

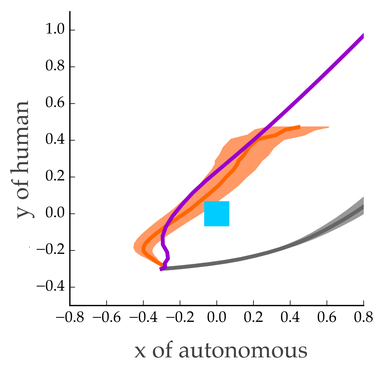
User Study Evaluation

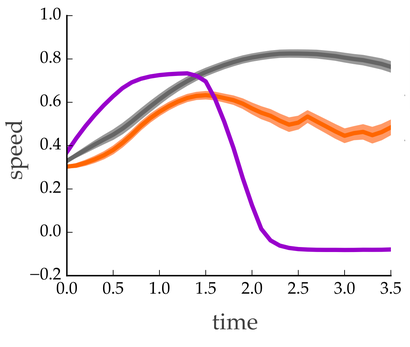


Car backs up at a 4-way stop; anticipates human ***proceeding****.*

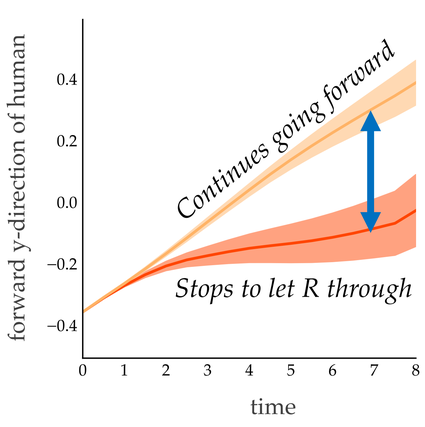


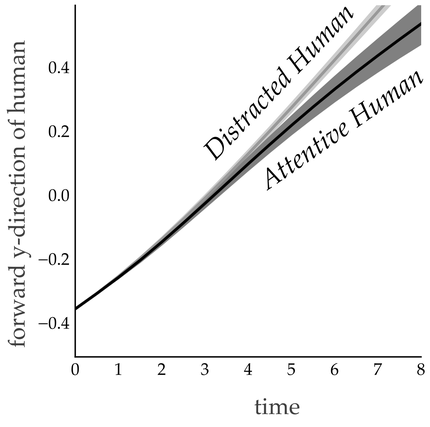
Car merges ahead of human; anticipates human ***braking****.*





Active Estimation of Driver Style





Info Gathering

$$r_R(x_t, u_R, u_H) = \mathcal{H}(b_t) - \mathcal{H}(b_{t+1}) + \lambda \cdot r_{goal}(x_t, u_R, u_H, b_t)$$

Changing Lanes

Information Gathering Actions over Human Internal State
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IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), October 2016.

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