Cultivating Safer and Smarter Roads: Resource Sharing for Enhanced Transportation in Autonomous and Semi-Autonomous Vehicular Networks

Bilal Taleb, Sara Mirza, Dr. Marcos Vasconcelos – Department of Electrical and Computer Engineering

Hypothesis:

Based on our outlined research, the integration of an intersection management infrastructure for autonomous vehicles will result in a substantial improvement in safety and efficiency at intersections when compared to situations where this infrastructure is not present. The prediction is that this infrastructure will serve to reduce the likelihood of collisions while simultaneously improving traffic flow, ultimately facilitating an easier transition of human- and autonomous-driven vehicles into the current road networks.

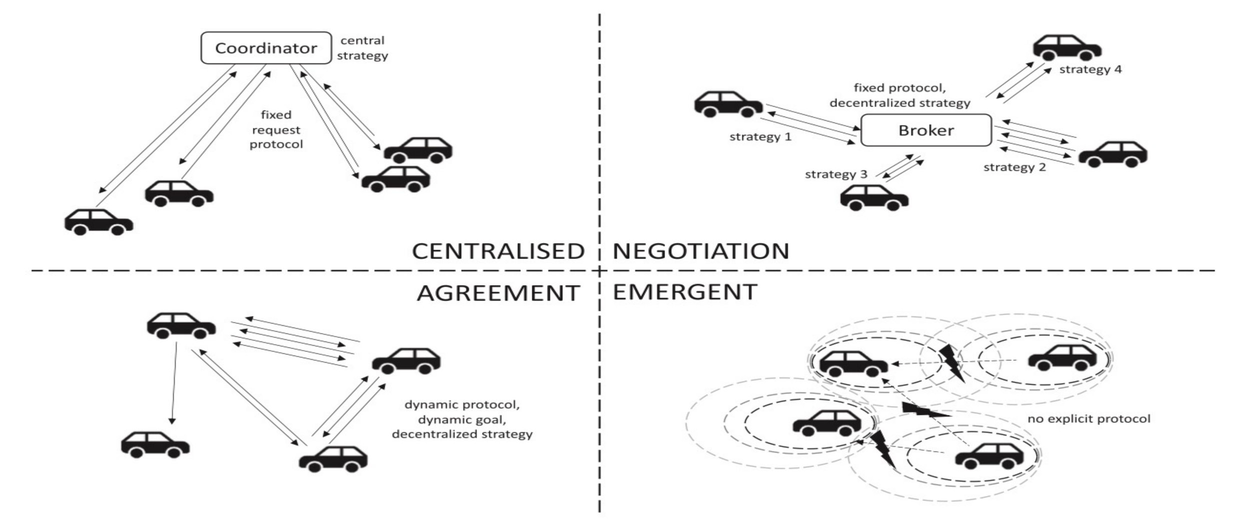
Abstract:

A complex socio-technical system is created when autonomous driving and human operations coexist, posing technical safety issues and possible ethical and legal dilemmas. This project targets autonomous and semi-autonomous vehicles, while addressing the issues of safe and effective transportation by *enabling resource sharing at the micro and macro cloud infrastructure levels*. Representative in this project are scenarios where an autonomous vehicle faces an intersection dilemma with the presence of a human driven car, while simultaneously taking into consideration how the vehicle should proceed in residing actions.

Table 3. Criteria for Definition of and Attribution to Autonomy Classes of the Coordination Approaches for Connected Autonomous Vehicles

	Strategy	Protocol	Role	Degree of Freedom
Centralized	external (coordinator)	fixed	passive	none
Negotiation	individual	fixed	active	admissible moves
Agreement	individual	dynamic	active	admissible moves, goals
Emergent	individual	none	active	full

The adjectives in each cell refer to the vehicles participating to the coordination process.



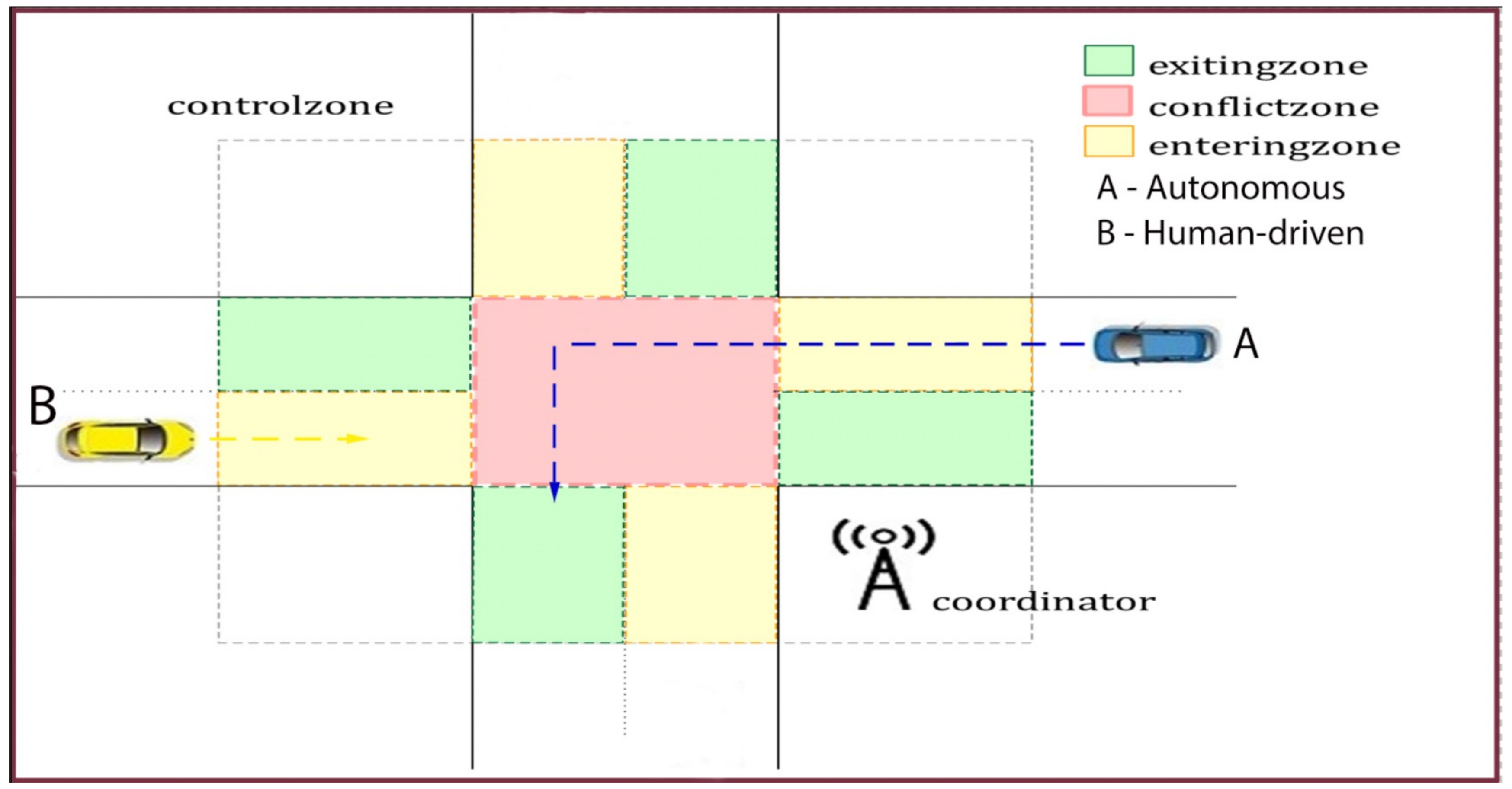
Introduction:

Autonomous vehicles today are still working to migrate into the current road systems consisting of human-driven cars. Currently, there is no infrastructure that helps to mitigate collision risks and assure safety in intersections. A potential infrastructure may include an intersection manager where autonomous vehicles will receive continual and directive instructions on how to proceed further, based upon information gathered from other resource-sharing vehicles on the road.

Methods

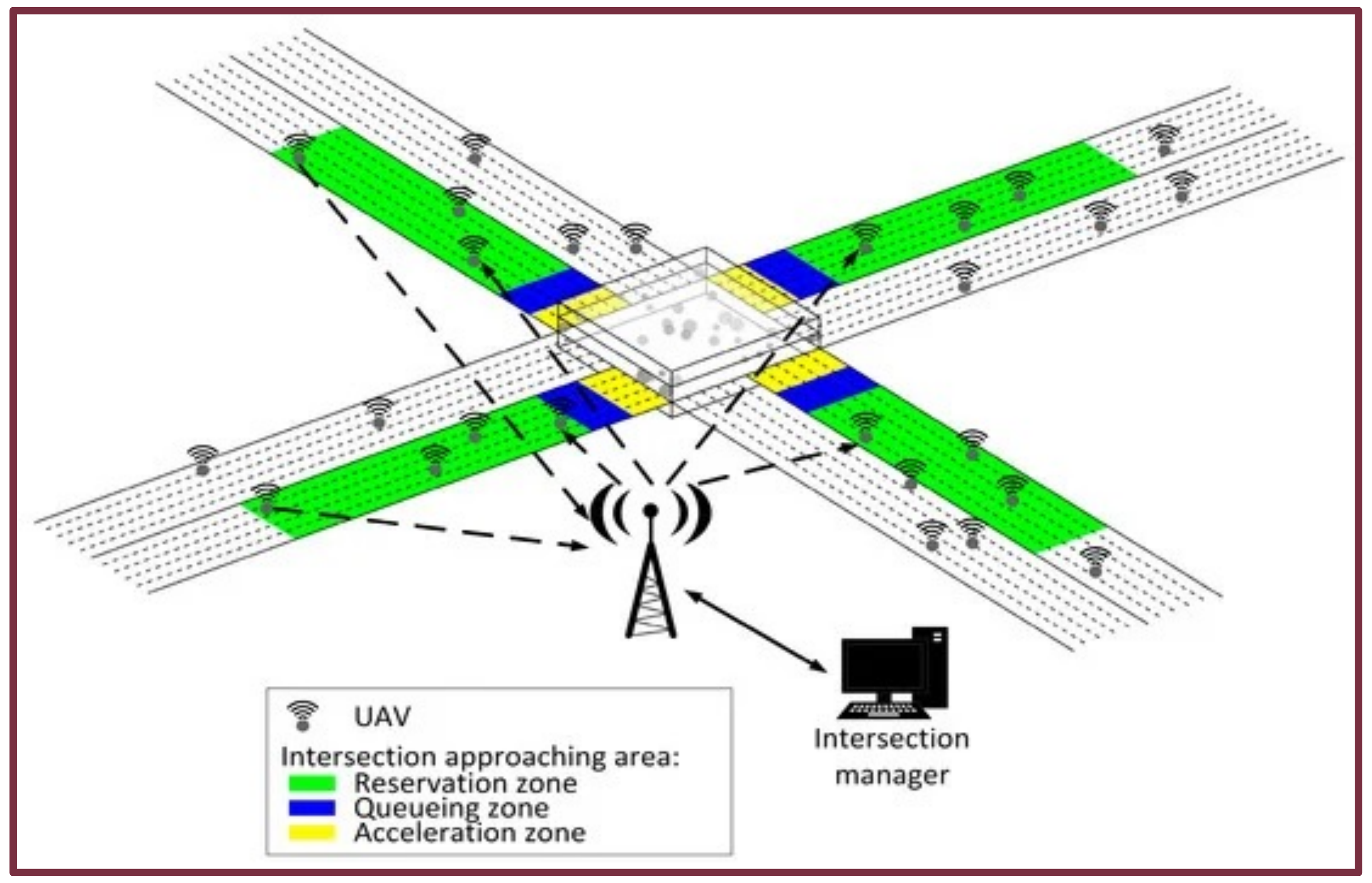
To collect an accurate measure of data and information to generate two varying solutions for this project, the use of previous research papers discussing V2V, V2I, and V2X communication systems is extremely pivotal. Hence, the utilized resources are listed below:

- GitHub Highway Environment Simulation
- Game Theory Algorithms
- Game Theory-Based Matrices



*The matrix shown *below* represents the payoff (+) and cost (-) of every potential scenario in the proposed intersection dilemma *above*.*

		A (Autonomous)			
		Forward	Turn Right	Turn Left	Stop
B (Human-driven)	Forward	(2,-10)	(4,-10)	(10,7)	(5,0)
	Turn Right	(2,4)	(4,4)	(10,10)	(5,4)
	Turn Left	(10,7)	(10,10)	(-10,4)	(5,4)
	Stop	(2,5)	(4,5)	(-10,-5)	(5,5)



Results / Findings:

Preliminary Findings

Thus far, it is predicted that in most scenarios:

- Human operational vehicles take riskier actions
- Autonomous vehicles are more risk-averse.

Our solution is to utilize the algorithmic features of Game Theory to aid the proposed simulation.

Future Directions

As this project progresses, the use of data found from the Game Theory simulation(s) will generate ideas on a potential infrastructure implemented into all vehicles. Additionally, the development of a *zero-infrastructure system* will stem from the initial solution. The prediction is that of these two solutions, our team will implement one of them into vehicles on the road to test their accuracy and efficiency in restoring universal safety.

References:

- Multicriteria Autonomous Vehicle Control at Non-Signalized Intersections, by András Mihály [1], Zsófia Farkas [2,*] and Péter Gáspár on 14 October 2020
- Stefano Mariani, Giacomo Cabri, and Franco Zambonelli. 2021. Coordination of Autonomous Vehicles: Taxonomy and Survey. *ACM Comput. Surv.* 54, 1, Article 19 (February 2021), 33 pages.
- Rubenecia, A.; Choi, M.; Choi, H.-H. Reservation-Based 3D Intersection Traffic Control System for Autonomous Unmanned Aerial Vehicles. Electronics 2022, 11, 309.
- Wuthishuwong, C., Traechtler, A. & Bruns, T. Safe trajectory planning for autonomous intersection management by using vehicle to infrastructure communication. J Wireless Com Network 2015, 33 (2015).