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Advanced Motion Prediction for Self-Driving Cars

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I. Short Bio

Miguel Ángel Sotelo received the degree in Electrical Engineering in 1996 from the Technical University of Madrid, the Ph.D. degree in Electrical Engineering in 2001 from the University of Alcalá (Alcalá de Henares, Madrid), Spain, and the Master in Business Administration (MBA) from the European Business School in 2008. From 1993 to 1994, he held an Excellence Research Grant at the University of Alcalá, where he is currently a Full Professor at the Department of Computer Engineering and Vice-president for International Relations. In 1997, he was a Research Visitor at the RSISE of the Australian National University in Canberra. His research interests include Self-driving cars, Cooperative Systems, and Traffic Technologies. He is author of more than 200 publications in journals, conferences, and book chapters. He has been recipient of the Best Research Award in the domain of Automotive and Vehicle Applications in Spain in 2002 and 2009, and the 3M Foundation Awards in the category of eSafety in 2004 and 2009. Miguel Ángel Sotelo has served as Project Evaluator, Rapporteur, and Reviewer for the European Commission in the field of ICT for Intelligent Vehicles and Cooperative Systems in FP6 and FP7. He was Director General of Guadalab Science & Technology Park (2011-2012) and co-founder and CEO of Vision Safety Technologies (2009-2015), a spin-off company established in 2009 to commercialize computer vision systems for road infrastructure inspection. He is member of the IEEE ITSS Board of Governors and Executive Committee. Miguel Ángel Sotelo served as Editor-in-Chief of the Intelligent Transportation Systems Society Newsletter (2013), Editor-in-Chief of the IEEE Intelligent Transportation Systems Magazine (2014-2016), Associate Editor of IEEE Transactions on Intelligent Transportation Systems (2008-2014), member of the Steering Committee of the IEEE Transactions on Intelligent Vehicles (since 2015), and a member of the Editorial Board of The Open Transportation Journal (2006-2015). He has served as General Chair of the 2012 IEEE Intelligent Vehicles Symposium (IV'2012) that was held in Alcalá de Henares (Spain) in June 2012. He was recipient of the 2010 Outstanding Editorial Service Award for the IEEE Transactions on Intelligent Transportation Systems, the IEEE ITSS Outstanding Application Award in 2013, and the Prize to the Best Team with Full Automation in GCDC 2016. At present, he is Past-President of the IEEE Intelligent Transportation Systems Society

II. Abstract

Self-driving cars have experienced a booming development in the latest years, having achieved a certain degree of maturity. Their scene recognition capabilities have improved in an impressive manner, especially thanks to the development of Deep Learning techniques and the availability of immense amount of data contained in well-organized public datasets. But still, self-driving cars exhibit limited ability to deal with certain types of situations that do not pose a great challenge to human drivers, such as entering a congested round-about, dealing with cyclists, or giving way to a vehicle that is aggressively merging onto the highway from a ramp lane. All these tasks require the development of advanced prediction capabilities in order to provide the most likely trajectories for all traffic agents around the ego-car, namely vehicles and vulnerable road users, in a given time horizon. This talk will present some innovative solutions for efficient motion prediction in the context of autonomous driving.

Predicting traffic participants trajectories is of major importance in autonomous driving applications, since it allows the controller to plan ahead the motion of the vehicle, avoiding collisions and making better driving decisions. In this work, we aim at socially-aware and socially-consistent vehicles and VRUs trajectory forecasting and interaction understanding. Accurately forecasting the motion of surrounding agents is an extremely complex and challenging task, considering that many factors can affect the future trajectory of an object. First of all, the variety and complexity of road scenes is immense and traffic scene dynamics can be extremely different among different, or even similar, scenarios. Therefore, one major challenge of developing prediction methods is to find comprehensive and generic representations for all common scenarios that can be encountered in the real world. Moreover, although deep learning based models have shown incredible forecasting abilities, it would be desirable to retain structural information and explainability, instead of relying on the black-box nature of these models. Motion forecasting

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must be socially-aware, i.e., it must consider the past trajectories and intentions of surrounding agents. However, one major open question in the field of motion forecasting is how to model such interactions among traffic agents. Understanding how the ego-vehicle actions might influence other actors' behaviors is essential for safe and comfortable motion planning of self-driving vehicles.

Additionally, these predictions must be consistent among vehicles and non-overlapping. This can only be achieved by deeply understanding the scene dynamics and the essence of interactions among traffic participants. On the other side, most deep learning based models used for trajectory forecasting operate on data of a fixed size and a fixed spatial organization, which impedes to obtain a general representation for inputs and outputs such that they can be flexible to the number and type of agent as well as transferable under different scenarios.

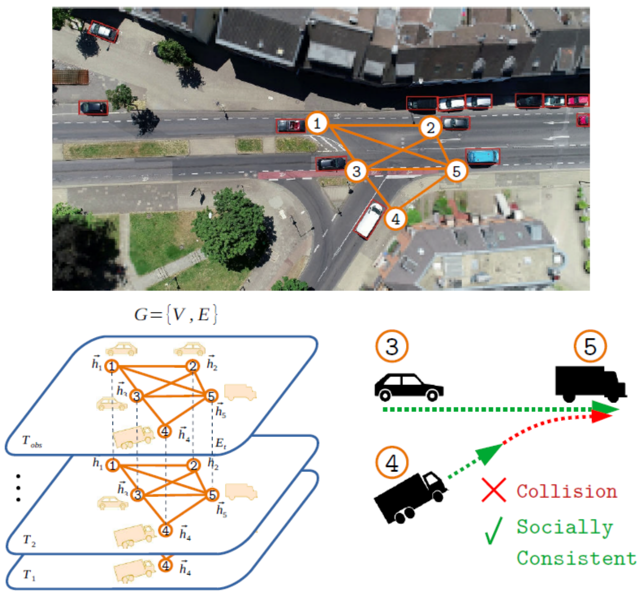

Figure 1: Spatiotemporal graph of an interaction scenario with 5 agents involved. Our approach predicts trajectories using an attention mechanism in a socially-consistent way.

In this work, we propose to tackle these problems harnessing the power of graph neural networks by modelling each traffic agent as a node and possible interactions between them as edges, obtaining a high-level representation of the traffic scene as a graph (see Fig. 1). In the light of the above mentioned, the main contributions can be summarized as follows:

- Socially-aware: we propose SCOUT, a generic graph-based formulation for modelling traffic interactions, where the influence of interactions among vehicles is modelled as an additional element that is dynamically learnt during the training phase in a semi-supervised way, following an attention mechanism.
- Socially-consistent: trajectory forecasts are learnt by incorporating the overlap of future trajectories as an element to be minimized during training.
- Flexible and transferable: our model works for a variety of number and type of road agents, while proving transferability among different scenarios.
- Urban dataset: this work has been evaluated with three real-world urban datasets, in which numerous interactions between various road agents occur simultaneously.
- Interaction understanding: the exploration of attention learned by our model sheds light on the interpretation of the influence of vehicle interactions on the final prediction.