Anthropocentric Development of Intersection Control Principles for Self-driving Vehicles under Considerations of Social Justice

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Abstract

Advances in communication, sensing, and in-vehicle computing technology in the last two decades have enabled the development of self-driving vehicle (SDV) technology. This technological development has a potential for revolutionizing traffic control technology. One of the questions for development of SDV technology is how these vehicles will interact in traffic, and especially at intersections, as critical points on the network. Alternatively to some previous research approaches, this research originates from the investigation of ethical dimension of the traffic control principles for SDVs. This approach is attempting to consider the development of SDV technology from a wider, sustainable perspective. Consequently, we will present the development of the traffic control framework that includes a perspective of social justice, emphasizing delay distribution. First, the paper will present methodological approach and foundational deliberations from one of the leading social justice theories in addition to human behavior considerations. This information will be used to establish a framework for the proposed traffic control mechanism. Furthermore, the paper will present information collected about the proposed framework based on surveys and interviews. Finally, we will present the framework redesign and recommendations for further research contemplation. The research presented here implies that there is a potential for development of traffic control principles which would enable end user responsibility in the control process.

Introduction

Advances in communication, sensing, and in-vehicle computing technology in the last two decades have enabled potential for development of self-driving vehicle (SDV) technology [1, 2]. Consequently, SDV will be able to perform all safety-critical driving functions and monitor roadway conditions for an entire trip, while the user will only be required to provide destination and navigation input [3]. This emerging technology promises several potential benefits [4, 5]. However, in addition to these potential benefits, the question of how SDVs will interact in traffic remains. Moreover, this question is especially important for intersections, as critical points on the network. Consequently, emerging SDV technology will also facilitate significant evolution in the possible structure and mechanisms of traffic control, potentially leading to a radically different traffic control technology – traffic control 2.0 (C2). Until now, there have been several research efforts in developing traffic control mechanisms for SDVs (review in [6]). All these efforts have technical approach to development. On the contrary, this research originates from investigation of ethical dimension of C2 development.

Ethical Design Dimensions

Initially, it may not seem obvious that traffic control contains a significant ethical dimension. However, the fundamental function of traffic control technology is to control (and hence restrict) freedom of movement in public spaces, by determining who receives right of way at a given time. The restriction of right of way is justified by one central goal of traffic control: to protect the life and limb of roadway users. In fulfilling this goal, traffic control respects the human right to life, one of the fundamental human rights recognized by the United Nations [7].

Consequently, traffic control technology both restricts and enables freedom of movement. Determining the right of way for some vehicles implies that other vehicles have to experience delay at an intersection, and thus have longer travel time to their destination. Furthermore, roads and intersections as typically publicly owned and maintained spaces are pure public goods [8], and should provide non-excludable and non-rival benefits to all people. This means that traffic control technology should respect rights to equal access to public services (another fundamental human right recognized by the United Nations [7]). In addition, the relations between traffic control principles and fundamental human rights are complicated by the fact that freedom of movement is often needed to fulfill other fundamental human rights, such as the right to life, the right to work, the right to leisure, the right to a standard of living adequate for health, and the right to education. For example, a person waiting excessively at an intersection on his way to the hospital might die; a person waiting excessively at an intersection might be late for an important job interview, leaving his family without income.
Considering that these rights are universal and fundamental for every human being, as prerequisite for carrying out life's plans, it becomes an imperative for traffic control technology not to promote unjust distribution of restrictions to these rights. Traffic control technology needs to take into consideration perspective of social justice, as a structure or framework for distribution of advantages and disadvantages in a society [9]. The paper will present the development of the traffic control framework that includes a perspective of social justice. First, the paper will present methodological approach and foundational deliberations from one of the leading social justice theories in addition to social science considerations. This information will be used to establish some points for C2 framework. In the following two sections, we will present the information collected about the proposed framework based on surveys and interviews. Finally, we will present the current development status and some recommendations for further research contemplation.

The Framework of Social Justice

In this research, the notion of justice is introduced through the theory of justice as fairness, developed by philosopher John Rawls [10]. In essence, Rawls developed his theory as a regulative framework, based on the two principles [11]:

1. Each person is to have an equal right to the most extensive total system of equal basic liberties compatible with the similar system of liberty for all.
2. Social and economic inequalities are to be arranged so that they are both to the greatest benefit of the least advantaged, consistent with the just savings principle, and attached to offices and positions open to all under conditions of fair equality of opportunity.

The first principle above relates to liberty, while the second principle relates to equality. Essentially, Rawls' framework is arranged to protect the inviolability of the user and maximize the benefits of the least advantaged in the complete scheme as equally shared by all. These guiding principles have been used to structure a framework for development of new technology.

Human Behavior Considerations

Considering that technology evokes and influences user's behavior, there is a need to take into consideration human behavior. These behavioral considerations originate from human tendency to cooperate, especially at a group level [12]. Social science research tells us that people cooperate:

- When there is direct [13] and indirect reciprocity [14];
- Because they care about the outcome to other people in the system or because of greater social goals [15, 16];
- If they perceive that other people cooperate [17];

- If the payoff from the cooperation and the degree of the common interest increase [18, 19];
- If the structure can be modified by the agreement among members [17, 20];
- If there is more and better communication among members [17, 21];
- If there is an opportunity to build reputation [14, 17, 22];
- If there is a sanctioning system [12, 16, 17, 23-29].

Priority System

Considering that the inviolability of the user is the most important point in this framework, this can be translated as emphasizing the distribution of delay among individuals, and not solely emphasizing the total delay for the approach or intersection. In order to protect the inviolability of the user, control principles are developed to allow for greater responsibility of end user in the control process. Enhancing end-user responsibility is envisioned to emphasize long-term and large-scale cooperation, for the mutual advantage of individual user and to support a just control structure. In addition, the framework needs to assure that there will be no usurpation of the system from central control or individual users.
The proposed framework of social justice is developed as a Priority System (PS). Using PS, a user is able to assign a Priority Level (PL) for each individual trip, besides inputting the destination for SDV. PLs are defined on the ordinal scale, ranking from the least important to the most important PL. Selection of individual PL allows control responsibility to be partially in the hands of the user. For example, one person would assign "very high priority" for his trip one day, due to the emergency that trip has (e.g., spouse in labor). The other person for the same day would assign "low priority" since the trip has leisure as a purpose. In the case when these two vehicles approach the same intersection at approximately the same time, the vehicle with "very high priority" would be the first one to receive right of way, relative to the vehicle with "low priority". The users in this situation might have respectively inverse roles in other situation, and would achieve the respectively inverse result. This is underlying an agreement between vehicles in a system of cooperative production – person A will yield to person B today when person B needs right of way, under agreement that person B will yield person A tomorrow, when person A needs right of way.
Selected PL is used as a numerical factor to determine the right of way for the SDVs approaching the intersection. The initial proposed operational principle of PL system is similar to the priority queuing principles [30]. Priority queuing principles assume N priority classes, ranked from low to high. Under this queuing discipline, a user is selected for service if it is the member of the highest priority class. However, the users within a class are selected upon FIFO principle. The complete description of the actual traffic control principles and consequent vehicle dynamics at intersection will be presented elsewhere.
However, in order to avoid user usurpation of the PS, there is a system of non-monetary Priority Credits (₡).₡ are lost or gained based on the PL selected, as in Table 1. In the initial assignment, each user should receive identical amount of ₡. The initial case was assumed that this should be 20 ₡. Spending/gaining of ₡ will be only through PL selection, with uniform rules for all users. Dynamic ₡ ceiling would be another feature of the mechanism that would allow the increase in the initial value of ₡, up to a predefined maximum value that individual user can have. Dynamic ₡ celling would support reputation building, since the increase in the celling would happen in the case when the user had no records of abuse of the system.

PL	1	2	3	4	5	6	7	8	9	10
₡	4	3	2	1	0	-1	-2	-3	-4	-5

Table 1: Initial ₡ system in relation to Priority Levels

In order to activate the highest PL, user can also use Emergency Priority Credits (E₡), which are intended to be used in emergencies, and are separate from ₡. The initial assignment of

E₡ would be different among individuals. The initial suggestion is that people with disabilities or special medical conditions should be assigned higher initial number of E₡, considering that these credits are used for emergencies, which are more likely to happen to these people. However, in order to protect against user usurpation, there should be a system for pre- and post-activation verification, with penalties for misuse. Details on the control framework model are presented in [31-34].

Information about Survey

In order to investigate the idea of PS, the research team developed an online survey (approved by Institutional Review Board VT IRB 13-1060). The purpose of this survey was to identify user perceptions related to the effects of intersections upon social justice, and elements of moral decision-making related to the intersections as public assets. Specifically, we were interested in knowing the opinions related to fulfillment of individual needs and rights that can be used as a part of intersection control mechanism for SDVs. Moreover, anticipated findings included opinions on the effect of traffic control technology on individual needs, rights, decision-making within a specific framework of social justice, and general attitudes for emerging SDV technology. The survey had total 239 participants, 56% being male and 44% female. Respondents' age was ranged from 20 to 80 years, with majority of respondents between 25 and 35 years. Respondents were mostly Caucasian, but all other racial groups were also represented. Most of the respondents had college education, with 54% having a graduate degree, and 32% having a bachelor's degree. Greatest share of respondents (36%) had annual income less than $27,000. In addition, 29% had income between $27,000 and $73,000, 18% had income between $73,000 and $147,000, 5% had income greater than $147,000, and 12% preferred not to answer. Half of the respondents drive regularly on urban streets, whereas 34% drive regularly in suburban areas, and 16% drive on rural highways.

Survey Results and Interpretation

First question related to the topic of the survey was asking participants to briefly describe their understanding of the term "better intersection control technology". The answers included: "Smarter" devices that adjust to the current traffic situation; Better education and understanding of human behaviour; Better rules and better enforcement; General improvement or broad technology (e.g., roundabouts); Specific operational requirement (e.g., quicker, economical, fuel efficient, safer, less pollution, less noise); Fairness (e.g., fair, moral, everyone happy); Does not know. Overall, this question showed that there is a sense of "common good" among subjects. In addition, it showed that subjects' perceptions are influenced by their perception of conventional technology. Moreover, there is a sense of "fairness" in traffic, so that no one should wait very long, but comments also showed a general opinion that this "better technology" is not implemented in practice. Next question was asking people to determine if traffic control technology impacts the fulfilment of their needs. The list of needs was in line with Maslow's hierarchy of needs [35], including physiological, safety, love/belonging, esteem, and self-actualization, with specific examples for each of the needs. Survey responses show that almost all people (96%) recognize the importance of safety at intersections, but other factors are also present – especially the issue of respect (26%) and morality (23%). Question number nine asked subjects if driving through a red light at an empty intersection because you are late for work is a wrong action. Results show that 33% of respondents are neither strongly opinionated, nor do they consider this an erroneous behaviour. This might imply that still a significant number of people would disobey the signal indication in the case of this important trip. Question number ten asked how important is to include principles of social justice into technology design. This question was asked early in the survey to obtain unbiased opinion based on the following survey questions. As a result, majority of respondents consider that it is important to include principles of social justice into technology design, with only 8% who find the principles completely irrelevant to be included.

Question number eleven asked about the effect from traffic control technology on safety, travel time and environmental effects. Majority of answers indicated that traffic control technology affects safety and travel time. However, only a quarter of responses identified a relation to the environmental effects. Other comments included frustration, anger, satisfaction, happiness, other people’s safety, people’s skills, and quality of a neighbourhood.

Question number twelve was related to the previous question, asking whether the respondent identified an effect on travel time, to identify a relation towards fundamental human rights. Human rights listed were right to life (e.g., while traveling to the hospital), right to work (e.g., while traveling to a job interview), right to leisure (e.g., while traveling to a movie theatre), right to standard of living adequate for health (e.g., while traveling to a dentist), and right to education (e.g., while traveling to school). As a result, 75% of people answered that at least one right is affected, and most often people recognize the relation to the right to life. In addition, other comments related to time usage, time planning, and life quality.

When asked under question thirteen if the user would pay to receive the right of way through the intersection before someone else, only 3% of respondents would directly accept to pay for their right of way through the intersection, with majority of those respondents with income greater than $73,000. The last question in this group asked if the user would accept waiting at an intersection if the timing was setup to benefit all the users. This question was asked for different trip purposes. From the results, we observe that 19% would accept waiting while going to a hospital, 38% while going to a funeral, 32% while going to a job interview, 49% while going to a grocery store or the beach, with 5% that would never do so and 35% that would always accept waiting. Other answers included that waiting is acceptable if it is predictable and only in non-emergency situations. However, the wording of the question might have introduced a bias in answers, since some respondents did not necessarily relate going to a hospital to an emergency situation.

For questions fifteen to seventeen, the users were asked to imagine the following scenario: “You are approaching a four-way stop intersection. At the same time, another vehicle is about to arrive to the intersection from a different street. You have a way to know a trip purpose for the person in that other vehicle. In addition, there is a mechanism for reciprocity – i.e., if you decide to let that other vehicle go through the intersection before you, you will receive the right of way next time in the near future.” Each question then asked the respondents to imagine a specific purpose for their trip, and answer whether they would let the other person pass if that person has different trip purposes (going to the hospital, a funeral, an interview, a grocery store, the beach). In the question fifteen, the user was asked to assume going to a vacation. As a result, 93% of respondents would let the other person pass if that person was going to the hospital, 68% if the other person was going to a funeral, and 58% if the other person’s trip purpose was an interview. This shows a clear willingness of majority to wait for generally important trip purposes. In the comments, some survey participants raised the issue of how will the system distinguish “real” emergency (life-threatening event) from other cases. In the next question, respondent had to assume his trip purpose was a job interview. In this case, 92% of respondents would let the other person pass if that person was going to the hospital while 55% of the respondents if that person was going to a funeral. Consequently, 23% of the respondents would let the other person pass if the trip purpose was a job interview, 10% if it was a trip to a grocery store, and 6% if the trip purpose was the beach. Comparing to previous question, there is a drop in the percentage of participants who would let the other person go in cases they are not going to the hospital. In question seventeen, respondent had to assume their trip purpose to be going to the hospital. Consequently, there is a drop in the percentage of users that would let the other person go – 77%, 17%, 8%, 4%, and 3%, for that user’s going to the hospital, a funeral, a job interview, a grocery store, and the beach, respectively. However, these percentages were determined based on the people that have selected some of the answers provided. On the contrary, 41% of the participants have not selected any of the options, which might imply that they would not yield to the other person.

For questions eighteen to twenty, respondents were asked to imagine if they could assign a Priority Level from 1 to 10 to their trip, comparing that number to Priority Levels of other vehicles to determine when the user will receive the right of way (assuming that 10 is the most important, and 1 is the least important). Moreover, the respondent was asked to imagine each individual has a certain number of non-monetary Priority Credits that are used to select Priority Level for the trip. This was the first time in the survey PS was briefly described, to obtain unbiased participant opinions. For question eighteen, the respondents were asked to provide examples of what the trip purpose would be when one assigns Priority Level 1 (extremely unimportant), Priority Level 5 (neutral), and Priority Level 10 (emergency). For PL 10, subjects stated medical emergency (threat to life or limb), very urgent situations, late for a flight/train/bus, late for important meeting, late for daughter's wedding, church meeting, and none. For PL 5, subjects stated work, school, shopping, visit friends, errands, funeral, traveling long distance, rush to help someone, late for meeting/event, errands, take/pick up child, post office, appointments, gas station, love problems, sport events, visit a sick relative, 5 min to spare, set arrival time. For PL 1, subjects stated leisure, vacation, groceries, going out, entertainment, social, shopping, errands, sport, dinner, gym, coffee, park, dog-park, more than 10 min to spare, and no time sensitivity. In the question nineteen, users were asked to provide their perceived PL for several trip purposes. The results are presented in Figure 1 below. From this figure, we can see that respondents used all PLs for every trip purpose. With further investigation, we could see that there was some small percentage of people that always selected high PLs. However, this implies that PL system could not operate without a supporting system, such as Priority Credits. In addition, we can observe the distribution of selected PL changing based on trip purpose (e.g., tendency to select lower PLs for shopping vs. tendency to select higher PLs for medical trip purpose).

The last set of questions started by asking respondents how Priority Credits should be initially assigned. As a result, 24% of respondents think everybody should have the same number, 22% of respondents think that credits should be distributed to meet the basic needs of everyone, 15% of respondents think that people with disabilities should have more credits, 14% of respondents were not sure, while 12% of respondents think that credits should be distributed to produce the greatest total amount of well-being in the world. Other comments included people in the greatest need (e.g., pregnant woman, very sick people) and that people should earn credits by allowing other people right of way. Again, there is concern of how to recognize people's emergencies in advance in order to provide them with more credits. In addition, there is the concern whether central planning might restrict freedom and whether credit operation is machine's responsibility. Finally, some users have identified the need to increase awareness about basic needs of everyone. When asked if they think that the mechanism for assigning the right of way at the intersection for SDVs should be publicly decided, 48% of people answered affirmatively, while only 23% answered negatively. In addition, when asked if they were willing to pay higher price for a SDV technology that will protect your human rights (e.g., by ensuring you receive the right of way in urgent situations), 31% of respondents answered positively, 31% answered maybe, and 38% answered in the negative. Finally, in question twenty three, when asked if they would provide support for including social justice into the development of control technology for SDVs, 34% of people would provide political support (e.g., voting, lobbying), 42% of all the respondents would provide social support (e.g., volunteering, public discussions), and 12% would provide financial support (e.g., donation, fund-raising). These results show that the majority is interested in providing support for development of broader vision in SDV technology, and might even be willing to invest in such technology.

In the last question, respondents were asked to provide comments or recommendations regarding inclusion of social justice into the development of traffic control technology. First, respondents identified some factors that might influence their PL selection. For example, in the cases of added urgency of the trip based on being late, or based on their emotional state. Second, respondents were providing some suggestions, such as, there is no need for many PLs, that PL 10 trips should be preprogrammed to go to the hospital, and that there should be a sanctioning system for people that always assign high PL. Third, respondents, although most of them recognizing that transportation facilities are a “common good”, expressed concerns if other users will be socially responsible. Furthermore, they were suggesting that users need to take into account inevitable delay in travel.

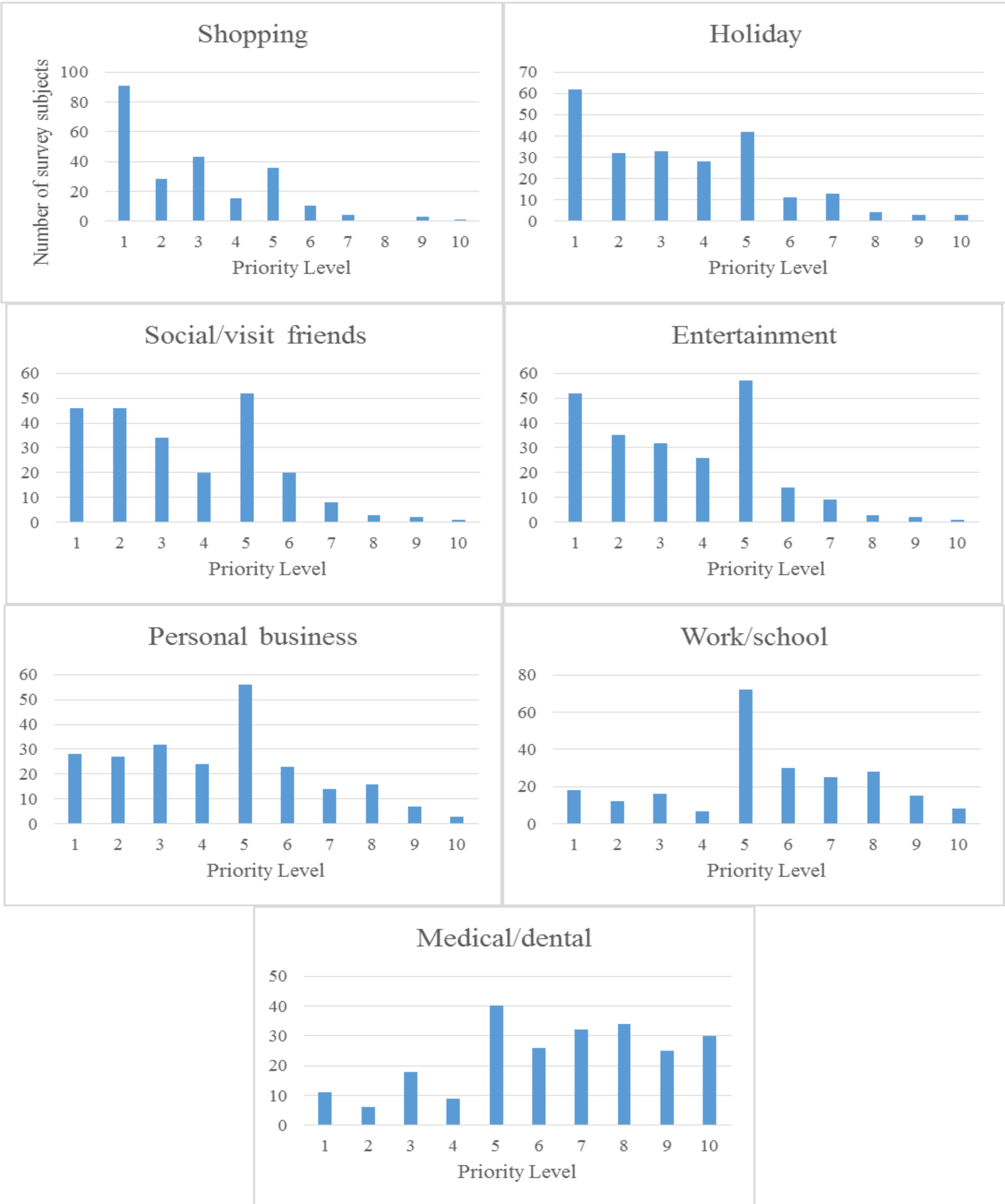

Figure 1: Distribution of PL assignment based on the trip purpose

In additional comments, respondents were concerned for the importance to include public transportation, public service vehicles (e.g., emergency, fire, and police), pedestrians, and bikes in the notion of SDV technology development. In addition, respondents were concerned with political influence and paying for service. Moreover, there were suggestions that development should take into account existing legislation for vehicles. A small number of respondents were suggesting “first-come, first-serve” principle instead of priority principle, and that development should not focus on social justice, but on throughput, travel times, and environmental effects, and that aiming at global efficiency will benefit everyone. Lastly, respondents suggested that more information on the system is needed, thus showing their interest in a further development.

Information on the Interview

In addition to the survey, research team decided to perform interviews (approved by Institutional Review Board VT IRB 14-140) for obtaining in-depth understanding of some crucial relations for system development. The purpose of the interview was to identify user opinion and decision-making related to the initial proposal of the intersection operating mechanism. Specifically, research team was interested in knowing the users' opinions related to the capability of the proposed operating mechanism to fulfill individual needs and rights. There were 33 participants in total. Participants' average age was 41, median 39, with oldest participant being 67 and youngest being 18. There were 19 male (58%), 14 female (42%) participants. Most of the participants had graduate education (15), 11 had a BSc, 1 BSc/some Grad, 3 Associate degree, and 3 some BSc. In addition, 29 participants were Caucasian, 2 African American, and 2 Hispanic. All participants had a driving license, with 26 driving almost every day, 2 driving few days per week, and 5 driving few days per month. Participants were mostly driving in suburbs (24%) and urban environment (24%), while there were also other combinations of driving environment present. Although the interviews were planned to last around 30 minutes, many interviews have lasted longer (up to 90 minutes), as the open-ended discussion with the subject was acceptable part of the interview.

Interview Results before Presenting Priority System

At the start of the interview, and before presenting any information related to PS, participants were asked to briefly describe their understanding of the term "better intersection control technology". Most of the responses focused on technology as being adaptive, responsive, with sensing and predicting capabilities, etc., and were frequently influenced by popular knowledge on traffic signals (e.g., having green wave). In addition, responses focused also on technology that can address efficiency (e.g., minimizing delay, improving flow, prevents unnecessary delay, managing queues), safety, and fuel consumption. Some participants commented that technology should support improved interaction among people and more intuitive instructions, which lead to better driver's behaviour. Finally, some participants focused on emotions (less frustration), being fair for side-street traffic, and improving delay for everyone, not just for a subset of users.
The following question asked participants how they perceive the impact of traffic control technology on their needs. Great majority of participants (97%) recognized the impact on safety. The one participant who did not recognize any impact on the needs, later on in the interview recognized the impact on safety. In addition, eight participants recognized the impact on esteem, six identified impact on psychological and self-actualization needs, and four identified a relation with love/belonging needs. In the next question, when asked does traffic control technology affect safety, travel time, and environment, 28 participants identified impact on all three, while five participants identified only a relation to safety and travel time.

Interview Results from Interaction with Priority System

After the initial questions, the participant interacted with PS. Each participant was presented a scenario of approaching an intersection in a self-driving vehicle. Each time, the participant was assigned a hypothetical trip purpose from the following: Holiday, Shopping, Social/visit friends, Entertainment/sport, Personal business, Work/school, Medical/dental. According to this trip purpose, participant was asked to pick one PL from one to ten. Each participant starts with 20 ₡ (max 25 ₡, min 0 ₡), and after PL selection, the ₡ number is automatically recalculated. In addition, the user is presented with a case of low, medium, or high traffic. In

total there were 21 trials, considering the number of combinations of trip purposes and traffic levels. However, each participant was presented with a random order of these combinations. Besides selecting PL, participants were asked to provide an explanation of their decision making and amount delay that would make them increase their PL. For cross-validation purpose, the participant was again assigned PL selection task after completing these 21 trials. This time, the participant was presented with all trip purposes in combination with low and high traffic scenario. The order of combinations was identical for all participants.
Figure 2 and Figure 3 below present number of total PL selections for low, medium, and high traffic and for each trip purpose. In addition, cross-validation cases were presented on the right, including only low and high traffic.

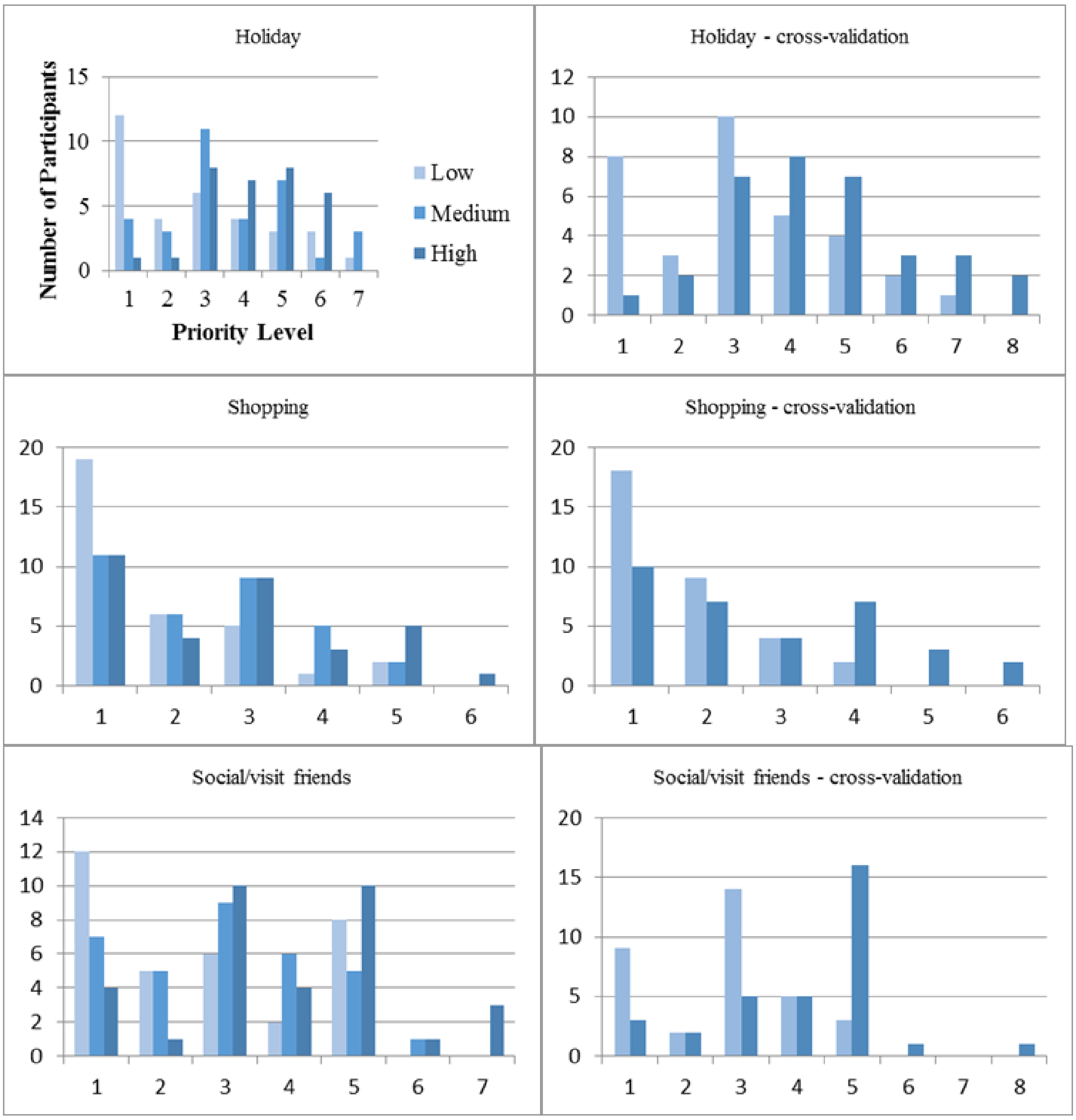

Figure 2: Distribution of number of PL selections for low, medium, and high traffic in the case of Holiday, Shopping, and Social/visit friends trip purpose

Similarly to Figure 1, we can see that different trip purposes have different distribution of PL assignment. People tend to select lower PL for holiday and shopping trip purpose, medium for social, entertainment, and personal business, while they assign high for work and emergency situations. However, we can see that there are no cases of selecting all PL for every trip purpose, with PL 10 present only in work and emergency trip purpose. Moreover, we can see that there are discrepancies between starting and cross-validation case, potentially originating from different decision-making procedure used by each participant.

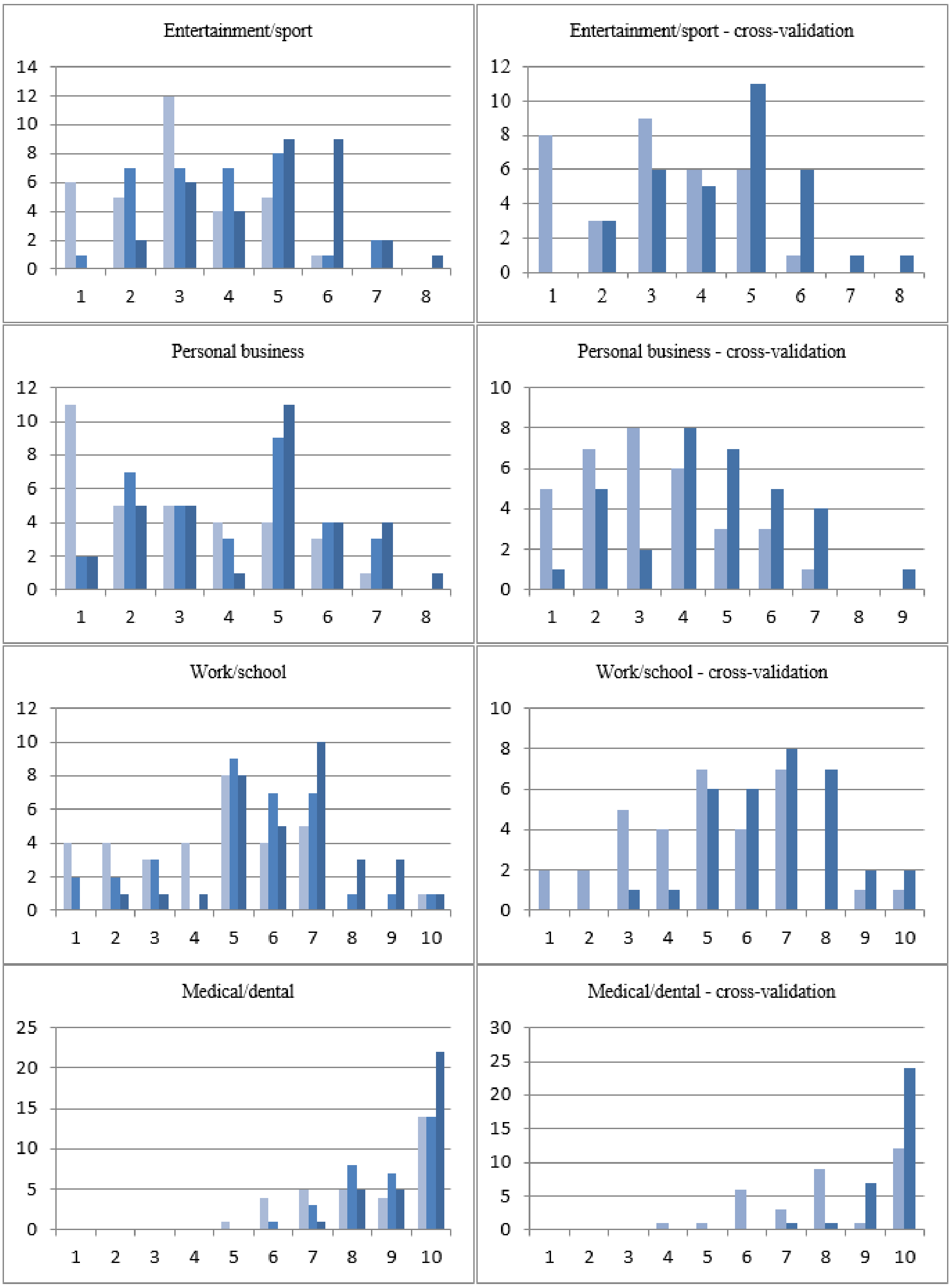

Figure 3: Distribution of number of PL selections for low, medium, and high traffic in the case of Entertainment/Sport, Personal business, Work/school, and Medical/dental trip purpose Interview Results after Interaction with Priority System

After completing the interaction with PS, participants were asked a series of questions related to the PS. Questions asked if the participants can think of the way to abuse the system solely for their own benefit, if there is a potential for failure of the system, if PS could operate differently, or to provide any other comments. We have to point out immediately that none of the participants had a completely negative opinion towards PS. We have grouped the answers as positive comments, comments about system failure, and factors influencing PL selection.

Positive comments:

- System could save time and lives, and have positive environmental effects.
- System is fair, identical for everyone, allows user to choose their own priority and can influence their travel time to destination.
- Credit system is good because it allows gaining and spending, it is non-monetary, deters abuse, allows people to save and plan the future.
- System accounts for actual situations through relative importance, and can include special vehicles.
- System could increase awareness of other’s needs and nudge people to think during trip planning.

System failure:

- Concern that some people do not think much about the future and will try to go around the rules.
- Concern that people will drive more to accumulate credits, use high PL for longer trips or during peak traffic, or aim to stay around maximum value of ₡.
- Concern about the actual effects on travel time.
- Concerns for operation in special situations (e.g., large events, bad weather).
- Concern for emergency situation in the case of lack of ₡.
- Concern for changes in routing choices (e.g., to accumulate ₡).
- Long-term psychological effects (e.g., if people become primarily focused on ₡ instead on people, if people are stimulated to compete in higher traffic, or if people start overvaluing their low PL selection).

Factors influencing PL selection:

- The level of pain (e.g., strained ankle vs. severe abdominal pain);
- Perception of available time (e.g., store is closing, movie is starting);
- Perception of trip purpose importance;
- Perception of traffic congestion and estimated travel time;
- Delay thresholds (e.g., delay as a ratio of total travel time and in relation to trip purpose);
- Other people in the vehicle;
- Esthetic experience of the trip;
- Perception from other people (e.g., selecting lower PL to avoid group pressure);
- Priority Credits available (e.g., temptation to use higher PL when having more ₡);
- Caring for other people not to use high PL;
- Willingness to complete trip (e.g., low willingness could result in selecting low PL);
- Culture (e.g., a custom to arrive before the event starts);
- Monetary relation (e.g., bought concert tickets);
- Trip chaining (e.g., going to shopping than picking up children).

Suggestions for System Development

In addition to providing comments on the current stage of system development, participants have provided a set of suggestions for system improvement.

- The system should be in a continuous development, with greater input from the public.
- There should be a capability to override the system in some situations (e.g., traffic congestion).
- ₡ should not be per vehicle.

- Everyone should be assigned the same number of ₡ or people with greater need should have a greater number.
- There should be smaller number of PLs.
- Spending/gaining ₡ should be based on trip duration or level of traffic.
- There should be capability to change PL during the trip, certain number of times or after some period of time, but number of ₡ used might depend on the scale of change in PL.
- There should be clear reward system for people that do not select higher PL over certain period of time (e.g., increase maximum number of ₡ or E₡).
- Default PL for emergency vehicles, public transportation, bicycles, and pedestrians should be higher than PL for passenger vehicles.
- Higher PL should cost more ₡.
- There should be a separate set of emergency ₡ and they can be spent if there is verification at destination (e.g., hospital).
- ₡ should reset after some time, or provide additional credits after certain vehicle's mileage or time.
- There should be free-market for buying and selling ₡. However there were also participants that are strongly against buying and selling ₡.
- There should be an option for donating ₡.
- Credit misuse cases should be publicly announced.
- System should require log-in for use.
- Provide incentive through ₡ gain/loss for people to use less congested routes.
- In the case vehicle is used to provide transport to some other user, ₡ should be used from transported user.
- Priority in a multi-person vehicle should be given to the person with the most important thing.
- Routine/every day trips should account for 0 ₡ or some default value.
- Vehicle could drive faster on the links based on PL or assigning routes based on PL.
- User should not be allowed to assign PL 10 many times in a row.
- Use additional ₡ to get to the destination in time and provide guaranteed travel time.
- There could be a rating system that would influence how much ₡ are gained or lost.
- If user selects a higher PL during the trip, ₡ are accounted for the highest PL, but if they select lower PL, ₡ are accounted for smaller PL.
- Provide examples of what different PL should be.

General Comments Related to SDV Technology

In addition to comments related to PS, participants have provided a series of comments related to SDV technology in general. First, participants have expressed many concerns about the safety of technology. In addition, some users were against autonomous vehicle in general, preferring to maintain overall control over their vehicle. On the contrary, almost all the participants recognize technological benefit for elderly, impaired and disabled users. In addition, they recognize that user in SDV is free to engage in other activities. However, participants have expressed certain level of understanding for decision-making irrationality in themselves and in other people. Consequently, they recognize the potential for change of lifestyle, change in departure time or trip rescheduling, but also potential for continuous adjustment of experienced delay expectations. Finally, participants were concerned with other technical points (e.g., at what point can user change her destination during the trip, influence on transportation system in overall by having more long-distance trips, and different ownership model for SDV use).

Conclusion and Recommendations

This paper starts with a point that the question of justice applies to technology in general, and consequently to the traffic control technology, since traffic control technology can affect the common good of the man by restricting the right to free movement and equal access to public service. Considering new technological tendencies in the communication, sensing, and in-vehicle computing fields that can enable further development of traffic control technology. In the case of traffic control, an alternative to the conventional control needs to include a perspective of social justice. We have started this paper by explaining the expanded "design horizon", with the reasons why a framework of social justice is an essential component. The central part of the paper presents a survey and interviews conducted to collect feedback on the proposed system design.

Survey has shown that users' perceptions are influenced by existing technology but that they perceive the effect traffic control technology has on all life aspects. In addition, survey has shown that there is a potential for development based on social responsibility, despite respondents' concerns and lack of trust in both technology and other citizens. However, the survey has shown us that Priority Level selection cannot exist without a supporting system.

Information from both survey and interviews have demonstrated that PL selection follows a certain global patterns, since people distinguish between low, medium, and high importance trip purposes. Moreover, the results showed us that people can behave altruistically and cooperatively, but that Priority System can also be resilient enough to the fact that people do not follow straightforward rational rules based solely on utility. Finally, we can conclude that there is a potential for development of control approach based on end user responsibility.

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