**Connected and Automated Vehicles Problem-Solving Course**
University of Michigan
Fall 2020

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We are delighted that you have enrolled in this course. This memo provides some background on our expectations for the substantive component of the course. (Professors Carr and Verhey-Hencke will provide separate information on the skills module component of the course.)

**The Law School's Interdisciplinary Problem-Solving Initiative**

In the Winter 2017 semester, the Law School launched a new problem-solving initiative with two pilot courses, including one on connected and automated vehicles ("CAV"). Fifteen graduate students from law, business, engineering, information, and public policy accepted the challenge of coming up with commercial use cases for data generated by connected vehicles using dedicated short-range communication ("DSRC") technology. At the conclusion of the course, three teams of five students presented their proposed use cases to a panel of industry and government experts in a capstone session.

In the Fall of 2017, we offered our second PSI Course in CAV—this one to 23 graduate students. That course focused on the problem of Level 3 automation, as defined by the SAE International (formerly the Society of Automotive and Aerospace Engineers). Level 3 automation, or conditional automation, involves the automation of key driving tasks within a specified operational design domain ("ODD") with a human user on standby to resume driving upon short notice when the vehicle exits the ODD. As with the first course, our student teams spent the semester collecting information from industry, government, and academic experts and proposing a series of innovative solutions to various obstacles to the deployment of Level 3 systems.

In the Fall of 2018, we offered our third course. Our 18 graduate students were challenged to identify key issues involving interactions between automated vehicles and other roadway users. Our three student teams chose to focus primarily on interactions between automated vehicles and vulnerable roadway users ("VRUs") such as pedestrians and bicyclists. At the close of the semester, they presented findings on such issues as

standardizing communication protocols and designing smart intersections to a panel of distinguished experts.

In the Winter of 2020, we offered our fourth course. Our 16 graduate students were challenged to explore data sharing and data competition in the CAV space. Each student was assigned to a team representing a particular stakeholder interest (municipal governments, insurance companies, automobile manufacturers, and components suppliers). Working first in their groups and then as a whole, the students presented a number of thoughtful ideas about data standardization, differentiation, and competition in their capstone presentation.

As we embark on our fifth semester in the PSI with a new CAV topic (described below), we look forward to welcoming graduate students from business, engineering, information, law, and public policy and interacting with faculty from other University units. Our goal is for students to develop cross-disciplinary cultural competence and learn to operate in collaborative spaces with an appreciation for the language, norms, perspectives, and practices of other disciplines. The program also offers students a chance to apply their subject matter expertise in practical ways in the service of solving big, emerging problems that matter.

We are also extremely grateful for the support and help of Mcity (mcity.umich.edu) and administrators in various other graduate departments.

**The Focus of this Course**

Our course this semester is entitled Connected and Automated Vehicles: Algorithmic Discrimination. Algorithms—processes or sets of rules followed by computers to solve problems—are foundational to modern life. More recently, machine learning has enabled a new generation of algorithms with the potential for further transformation, including in the realm of driving. The automated vehicles that are currently under development present opportunities—as well as challenges—to a vision of safer, more inclusive, and more sustainable ground transport.

Transport is inextricably intertwined with issues of social justice, and here too algorithms present both opportunities and challenges. Urgent conversations unfolding about the historical and present mistreatment of Black people, Indigenous people, and People of Color underscore that human decisionmaking often involves invidious discrimination, both in intent and in impact. Automated driving algorithms based on machine learning could mitigate and reduce or exacerbate and expand this discrimination.

Consider the example of pedestrian safety. The race of a person crossing a street may affect the respect they receive from passing motorists. Perhaps automated driving systems will be designed to respect the safety of all pedestrians. Or perhaps a combination of biased or homogeneous training data, technical challenges, algorithmic opacity, and Silicon Valley privilege will result in automated driving systems that are even less likely to properly recognize and respect Black pedestrians.

Similar questions can—and should—be asked about other aspects of automated driving. Will computers learn to recognize certain kinds of human faces, body shapes, habits, or movements more than others, thus imperiling those in the minority? Will automated taxis avoid certain neighborhoods because the data tell them that the risk is too great or the reward too small? Will mapping systems steer vehicles toward or away from certain routes in ways that disadvantage residents in certain communities?

The goal of our class is to identify key issues of algorithmic discrimination in automated driving and begin working toward viable solutions. In order to focus the class's problem-solving efforts, students will be assigned to one of four groups. Each group will at least initially focus on one of the following problems:

**Group 1. Training data in automated driving**: In a phenomenon politely called "garbage-in/garbage-out," an algorithm is only as good as the data on which it relies. This is especially important—yet potentially less traceable—in the case of machine learning. Automated driving systems rely on vast data sets, many of which involve significant human input and others that may eventually evolve with limit human oversight.

**Group 2. Edge cases in automated driving**: Assumptions commonly made about human drivers may not apply to algorithms. For example, we might reasonably assume that a human driver who correctly identifies and appropriately responds to a stop sign at noon will also correctly identify and appropriately respond to a yield sign at dawn. In contrast, an algorithm that has never encountered a yield sign at dusk may respond in an unexpected way. More extreme edge cases could disproportionately involve and impact people who are outside the dominant community. Indeed, a homeless woman pushing a bike with bags across a suburban street in the evening was the first person to die in a collision with an automated vehicle undergoing testing.

**Group 3. Routing in automated navigation**: People have long complained that automated navigation systems like Waze negatively impact their communities by shifting motorists from arterials to local streets. Communities have frequently fashioned successful responses, while others have struggled. Conversely, some merchants who depend on foot traffic have objected that some navigation apps can deter pedestrians from walking down their streets. Power, race, and perception figure prominently into these experiences, which could become even more significant when automated driving deploys with automated navigation.

**Group 4. Access bias in automated mobility**: Many developers of automated vehicles envision initially deploying their systems in limited areas that are both technically feasible and economically attractive. This could further disadvantage communities that are already served poorly by contemporary transport policy. This evokes the challenges and opportunities presented by bike and scooter sharing systems—but could involve more technical complexity and less local oversight.

**Instructor Roles and Availability**

Dan Crane, May Liang, and Bryant Walker Smith are the primary course instructors. Ian Williams, the Fellow in Law and Mobility, will also be actively involved in the course. Each group will be assigned Dan, May, Bryant, or Ian as a primary facilitator. The primary facilitator is not a member of the student team—the students own it! His or her job is to be a resource for the team on such matters as identifying outside experts to contact, refining research questions, or navigating the challenges of working remotely. However, all course instructors are available to all students and all groups, so please do not hesitate to reach out to any of us.

Bridget Carr, Associate Dean for Strategic Initiatives (carrb@umich.edu), heads the PSI program. Andrea Quinn (amquinn@umich.edu), Assistant Director of the Problem Solving Initiative, is available to work with teams on various aspects of course organization and logistics.

Professors Carr and Verhey-Henke run the problem-solving skills module that meets the first three weeks. Any questions about them should be directed to Professors Carr and Verhey-Hencke.

**Course Goals, Expectations, and Deliverables**

This class will be very different from others that you have taken at the University of Michigan. [Part of the difference will come from being online.] The first three weeks will be taught primarily by Professors Carr and Verhey-Henke, and are largely trans-substantive and skills oriented. Your course instructors from the substantive portion will participate in those first three weeks, and assignments for the substantive portion will be due on the second and third day of class, in addition to assignments for the skills portion of the course (see schedule below).

Beginning September 22, the course will be taught exclusively by the substantive instructors. Given the compressed schedule (ending before Thanksgiving), things will move very quickly. We are providing a structure that we hope will allow each of the groups to hit the ground running and be prepared to contribute to the capstone presentation on November 17.

Each week of the substantive portion of the course, there will be at least one hour of time dedicated to working in teams and up to two hours of joint class time. We provisionally plan to run the joint class time 3:15-5:15, and group time 5:30-6:30, but that may vary based on the needs of outside speakers.

This is very much a group-based and team-based class. Most group-based work will take place in four interdisciplinary teams that will be formed before the first day of class (which is necessary for the skills-based portion of the course). We recognize that some students may drop or add the course, and that may necessitate some group reassignments. Please be flexible in your expectations! In addition to the four interdisciplinary teams,

we will sometimes break into three disciplinary groups: (1) law, (2), technology, and (3) business and policy.

Joint class time will consist of substantive discussion principally led by each group and sometimes augmented by outside experts. Group work time will be used flexibly by each group to work toward the group's assigned topic and, in particular, to liaise with the four of us. Each group is expected to identify and interview experts on their assigned topic, and some of those interviews may be scheduled during group work time. Note, however, that groups are expected to do the bulk of their work outside of class.

The ultimate deliverable in the course is a capstone presentation that will incorporate each team's proposal on its assigned topic. Past presentations will be made available for reference. Ideally, each group's section of the presentation deck will consist of some overview slides identifying the nature of the problem and a few slides containing the group's problem-solving proposal.

Given the sprawling nature of the problems under consideration, teams need not feel like they must offer a proposed solution to the entire issue. A novel, creative, and detailed solution that addresses one angle on the problem is preferable to an attempt to cover the entire issue with re-hashed generalities. Ideally, each team will identify a key challenge or opportunity related to your topic, propose a concrete and original idea in response, and present it in a way that allows experts to engage in a deep and meaningful way. We don't expect you to solve the whole problem. Maybe you will identify a small but previously unnoticed piece of the puzzle. Maybe you will come up with a new technical or legal tool to address it. Emphasize innovation. We don't want, and won't accept, just another report summarizing what a dozen other reports have already said and describing the same set of superficial strategies that are applied to every policy issue. Make us think! Make us disagree! Move us forward!

In keeping with the interdisciplinary nature of this class, we urge you to think broadly about the dimensions of the problem you will tackle. Law, business strategy, technology, public policy, information science, ethics, and whatever other skills and competences are reflected in your groups all belong in the discussion.

For the capstone presentation, the class as a whole will present its proposal to a panel of distinguished external experts from industry, academia, and government who will then engage in a moderated discussion with the students about their semester's work. Presentations are most successful when they provoke thoughtful reactions from the panel. The goal is not so much to persuade the panelists that a particular proposal is feasible or effective, but to showcase create, interdisciplinary problem-solving approaches and stimulate a dynamic conversation.

**Schedule and Logistics**

- **September 1**: Virtual Problem-Solving Module

  **Skills Module Assignment**

  - Before 1st class:(Problem Solving 101: Interviewing)
  - We will be using Mural.co for this course. Please complete a 1 hr training on this technology before the first day of class. You may sign up for a training at this link. Trainings are offered throughout the week, please sign up soon to make sure you have it done before we meet! https://mural.zoom.us/webinar/register/WN_Ni7NbEQqTiOlj1RStKv3kA
  - Please review the slides "Interviewing for Insights"

  **No Substantive Module Assignment**

- **September 8**: Virtual Problem-Solving Module

  **Skills Module Assignment**

  - Before 2nd class (Problem Solving 101: Brainstorming):
  - Please watch the Ecosystem Lecture (ann is creating this right now) and with your group complete your Ecosystem map
  - If you have not previously completed a social identity wheel please watch and complete the exercises (including the wheel) in the Community Engagement: *Collaborating for Change* MOOC. You only need to watch and complete a portion of Module 2 Section 1. You may stop at the section entitled "Dimensions of Social Identities Continued". A link to the MOOC can be found at the bottom of this webpage: https://ginsberg.umich.edu/article/community-engagement-collaborating-change
  - For the problem your group is solving write down ten solutions or thoughts you have about the issue on post-its on Mural.co. On each post-it put down your initials in the bottom as well as an abbreviation for your discipline (ex. PH for public health, SW for social work, etc.)

  **Substantive Module Assignment**

- Reaction paper for Reading Cluster 1 due—e-mail to dancrane@umich.edu (assignment described under Readings below).

- **September 15**: Virtual Problem-Solving Module

  **Skills Module Assignment**

  - Before 3rd class (Problem Solving 101: Prototyping)
  - Each group should have completed and picked their How Might We Statement. It should be on your mural.com board before class today. Ann and I will be holding office hours if you need help finalizing your statement

  **Substantive Module Assignment**

  - Each group should submit a bibliography of at least 10 sources (articles, cases, reports, data sets, websites, speeches, software programs, etc.) that the group has consulted bearing on their assigned topic, together with a paragraph about the relevance of the topic. (Again, that's one submission per group). No more than three of these may be drawn from Reading Clusters 1 and 2 (below). Each group should also list the names of at least 5 individuals with expertise in the assigned topic that the group might interview. Email assignment to dancrane@umich.edu.

- **September 22**: **Beginnings.** Each interdisciplinary group presents what it knows or has already learned about our substantive topics: (1) automated vehicles, (2) artificial intelligence, (3) discrimination generally, and (4) algorithmic discrimination specifically. Each group to give a 10-minute presentation on one of the topics. Emphasis on importance of (1) finding appropriate sources and (2) citing those sources. (ML)

- **September 29**: **Discrimination in the disciplines**. Each discipline-specific group presents on (1) the meaning of ethics, (2) key issues of power/privilege, and (3) quintessential examples of discrimination (all from within their discipline). Presentations on meanings of discrimination in law and ethics by Margo Schlanger and Ben Kuipers, University of Michigan Computer Science. Each interdisciplinary group to update the class on the progress they have made in understanding the challenges related to their specific topic (including expert interviews and other research) -- "here's what we've done, here's what we've learned, here's what we're wondering, here's what we're thinking, here's what we're planning." (DAC)

- **October 6**: **Tools and Resources**. Background reading on safety-/privacy-/x-by-design. Our discipline-specific groups present on (1) the ways that their discipline accounts for and influences individual and institutional behavior through principles, processes, and incentives (e.g., human factors in engineering, liability in law,

organizational design in business, norms in public policy) and (2) identifies key resources within their discipline that could be important to this course (e.g., experts, standards-setting organizations, local advocacy groups). We discuss how this applies to algorithmic discrimination both generally and in the case of automated driving specifically. Our interdisciplinary groups update the class on the progress they have made in understanding potential opportunities related to their specific topic (including expert interviews and other research) -- "here's what we've done, here's what we've learned, here's what we're wondering, here's what we're thinking, here's what we're planning." (BWS)

- **October 13**: **Scoping**. The interdisciplinary groups present on their topics, especially (1) a research-based explanation of the topic, (2) an overview of the key challenges and opportunities, (3) an initial concrete scope (e.g., "[this specific challenge] is the key to this topic and where we plan to focus our effort" or "[this specific idea] seems especially promising in addressing this topic and is where we plan to focus our effort" or "we've actually moved away from our original topic into [this new topic even if it was originally assigned to another team] because we're really excited by [this particular angle]"). (BWS)

- **October 20**: **Progress.** The interdisciplinary groups provide a brief update to the whole class and then spend the rest of the session rotating among the four instructors for intense discussions. (DC)

- **October 27**: **Proposals.** The interdisciplinary groups present a much more developed version of their key insight or idea within the scope they identified. The discipline-specific groups meet briefly and report back on their suggestions (regarding both challenges and opportunities) for each interdisciplinary group. The class identifies gaps--particularly missing voices (e.g., experts or impacted communities)--and collective next steps for filling those gaps. (ML)

- **November 3**: **Presentations.** The interdisciplinary groups practice the presentation they plan to give for the capstone, including (1) a short summary of their general topic and (2) a developed pitch for their specific idea. The class offers feedback on both substance and style. The class practices asking questions. The groups coordinate with each other on coverage, duplication, and consistency. We discuss all the deliverables for the course (presentation, mural, evaluations, etc.). [1] (BWS)

- **November 10**: **Dry Run.** Final preparations for capstone. Each group should have a capstone presentation draft ready to go. Dry run, group discussion, pulling final pieces together. (ML)

[1] November 3 is Election Day. We strongly encourage everyone who is eligible to register and vote. We also recognize that some students may be absent from class due to Election Day activities. Closer to November 3, we will poll the class to see if any students will need to be absent and, if so, may shift some or all class activities to other times.

- **November 17**: **Capstone.** Groups have pre-recorded audio/video presentation with slides, no more than 30 minutes total. Online capstone will begin with playing of capstone presentation to panel of distinguished experts. Then, BWS will lead panel discussion about presentation and topic of algorithmic discrimination more generally with panelists and students. (BWS)

- **November 24**: **Reaction and reflection.** What did we learn about algorithmic discrimination from the capstone presentations, the panelists reactions, and our work this semester? What did we learn about interdisciplinary problem-solving? What avenues for future research or projects did this semester open? (DC)

**Background Readings, Reaction Papers, and Class Presentations**

There is only one set of assigned background readings—those in Reading Cluster 1—which will require students to submit individual reaction papers. A reaction paper does not need to be long—a single, double-spaced page can suffice. It should not summarize the assigned reading, but rather provide the student's reaction. Examples of reactions include the following: "I was intrigued by Prof. X's suggestion that Y is a problem, but I wondered whether Z might be a better way of framing the question." Or, "I didn't understand the technology behind A, and, having done so further reading, now understand it to mean . . ." Or, "having read these articles, I've decided the following kinds of people would be important to talk to. Here are some names that I've found . . ." As noted in the schedule above, student reaction papers to Cluster 1 readings are due on the second day of class.

The readings in Cluster 2 are not neither mandatory nor exhaustive—they are just a list to get students going for the assignment due week 3 and thereafter.

*Reading Cluster 1*

- Lance Eliot, *Overcoming Racial Bias In AI Systems And Startlingly Even In AI Self-Driving Car,* https://www.forbes.com/sites/lanceeliot/2020/01/04/overcoming-racial-bias-in-ai-systems-and-startlingly-even-in-ai-self-driving-cars/#31105d0723b7

- David Danks and Alex John London, Algorithmic Bias in Autonomous Systems, https://www.ijcai.org/Proceedings/2017/0654.pdf

*Reading Cluster 2*

- Hazel Si Min Lim and Araz Taeihagh, *Algorithmic Decision-Making in AVs: Understanding Ethical and Technical Concerns for Smart Cities*; https://arxiv.org/pdf/1910.13122

- Sam Huang, *The Racist(?) Autonomous Driving Car and the Dangers of Bias in Artificial Intelligence*, https://medium.com/predict/the-racist-autonomous-driving-car-and-the-dangers-of-bias-in-artificial-intelligence-9bfca178e658
- Greg Allen, *Understanding AI Technology,* (https://www.ai.mil/docs/Understanding%20AI%20Technology.pdf)
- Bryant Walker Smith, *How Governments Can Promote Automated Driving*, (PDF pages 10-17 of https://ssrn.com/abstract=2749375 or, for anyone interested in a longer nontechnical explanation, https://youtu.be/zDmYZX-6F28)
- Tim Miller, Piers Howe & Liz Sonenberg, *Explainable AI: Beware of Inmates Running the Asylum*, (https://arxiv.org/pdf/1712.00547.pdf)
- Comments of the Electronic Frontier Foundation Regarding Proposed Rules for HUD's Implementation of the Fair Housing Act's Disparate Impact Standard, (https://www.eff.org/files/2019/10/18/2019-10-18_-_eff_comments_on_hud_nprm_on_disparate_impact_-_final.pdf)

Beginning September 22, we will offer weekly slots for individual students to make a short presentation of no more than three minutes on additional research that you believe is relevant to the problems we are trying to solve. An online sign-up system will be utilized. Each student will be expected to present at least once over the course of the semester. Further presentations are optional. The ideal presentation: (1) briefly summarizes the key point or points of the research material; (2) explains its relevance to the course; and (3) suggests any follow-up steps for the presenter, a group, or the class. It is up to each presenter to select the material. It could be any material you feel relevant. Examples include, but are not limited to:

- Article in popular media.
- Technical report about a new technology.
- Article in a professional or technical journal or publication.
- Judicial decision, statute, or regulation.
- Government report.
- Analyst report.
- Patent application.
- Chapter of a book.
- Conference or webinar presentation.
- Interview with a subject matter expert.

As with your research more generally, we particularly encourage you to find relevant insights from your own discipline that you "translate" so that your classmates understand what they mean and how they help.

Presentations will count toward your final course grade.

## Team Organization and Work Product Sharing

By the second class, each team should have selected a team representative to serve as a liaison with other teams regarding shared work product. Teams should use Mural for organizing their work over the course of the semester.

As individuals or teams create work product—e.g., interview memos, article collections, shared presentation drafts, etc.—they should post them in appropriate folders in the shared site. Instructors, students, and administrators should have shared access to the class's work as it unfolds.

## Grading Expectations

We recognize that grading a non-traditional course largely based on collaborative work and team presentations is challenging. However, it is not unprecedented, and we have worked with CRLT to develop grading metrics that we believe are workable and fair. This course is not bound by the Law School's grading curve, so grading is not a zero sum game.

We will provide further details about aspects of grading as the course progresses, but here are the key components that will be reflected in assessing final grades. Note that the following are the components of the portion of your grade that will be based on the substantive section of the class, which will count for two-thirds of your grade overall. One-third of your grade will be based on a score provided by Professors Carr and Verhey-Henke for the skills module.

- **Team work product (35%)**: Did the team's work product demonstrate excellent judgment and superior research, analysis, critical thinking, and problem-solving skills? Did the team express its thoughts in an organized manner? Did the team's written and oral work product employ proper grammar, sentence structure, and vocabulary? Did the team's work product respond effectively to potential challenges and positions expressed by others? Did the team contribute significantly to the success of the overall plan or strategy?
- **Team functioning (10%)**: Did the team display cooperation and effective communication? Did the team function effectively and utilize skills and knowledge of all team members? Did the team consult with the professors and other knowledgeable experts appropriately? Did the team meet established deadlines?
- **Individual effort and interaction with group (20%)**: [Note: Input for this portion of the grade will be obtained from peer assessment forms, but the professors will have ultimate responsibility for this assessment.] Did you attend group meetings consistently and arrive on time? Did you contribute meaningfully to group discussions? Were you open to, and respectful of, other points of view? Did you complete group assignments on time? Was the work you prepared for the team high quality? Did you demonstrate a cooperative and supportive attitude? Did you contribute significantly to the success of the project?

- **Individual participation and professional relationships (15%)**: Did you participate regularly in class discussions and pose questions to speakers? Were you prepared to discuss developments in your projects in an effective manner with other students? Did you respond courteously and with due consideration to professors, guests speakers, consultants, and classmates? Did you strive for cross-disciplinary cultural competence (i.e., and appreciation for the language, norms, perspectives, and practices of other disciplines) and understanding of other differences among your classmates? Did you display honesty and integrity? (Honesty and integrity are, of course, basic expectations.)
- **Reading presentations and reaction papers (20%)**: Assessment of 3-minute presentations based on relevance of material presented and clarity and effectiveness of presentation; assessment of reaction papers based on evidence of having read assigned materials and thoughtfulness of questions presented.

We encourage you to document your work throughout the semester. (As our law students know: Good lawyers keep good records.) We reserve the right to recognize outstanding work (in either direction) in the final grades.

**Course Philosophy**

Although this course does involve some linear delivery of prepared content typical of a graduate level seminar, the most important learning will happen in your individual groups, much of it outside of class as you research, interview experts, and learn from each other. The goal is for *you, the students*, to come up with solutions to big problems in the world, working on a multidisciplinary team. We, the instructors, aren't sitting back hiding the answers. We don't have them. Really. We see ourselves as facilitators, conveners, project leaders, and (occasionally) experts, but *you* are ultimately running the show.

Please enter this course with a spirit of flexibility, creativity, and ingenuity. Remember that our goal is to mimic the best kind of problem solving in the real world: teams combining people with different expertise, ideas, strengths, and backgrounds pooling their ideas, time, sweat, and muscle to get things done.

We are tremendously excited about this course and the future of CAV. We hope that you are, too.

D.A.C.

M.L.

B.W.S.