Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency

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Overview

Timeline:
- Project start date: 10/01/2020
- Project end date: 12/31/2023
- Percent complete: 10%

Budget:
- Total project funding
  - DOE funding: $2M
  - Cost share: $0.5M
- Budget Period 1 Funding:
  - DOE funding: $833,133
  - Cost share: $330,335

Barriers:
- Lack of human factors understanding of user acceptance of pooled rideshare
- Lack of computational modeling of user acceptance of pooled rideshare
- Lack of human factors incorporated technologies design for pooled rideshare
- Effective validations of the pooled rideshare technologies and energy impacts

Partners:
- Clemson University (Lead)
- Argonne National Laboratory (ANL)
- J.D. Power
- Ford Motor Company
- International Transportation Innovation Center (ITIC)
Relevance

Challenges:
Low user acceptance of pooled rideshare limits the energy impacts of future mobility service seeing that most vehicles would still be occupied by less passengers. Two major challenges are
1. Lack of comprehensive understanding of human factors in pooled rideshare (PR)
2. Missing considerations of human factors in pooled rideshare technologies design

Objectives/Impact:
The goal is to increase the PR user acceptance by at least 30% and increase the efficiency of the transportation system by at least 15%. The objectives with impacts include:
• Human factors data collection on pooled rideshare through user studies
• Human factors barrier analysis and theoretical modeling of pooled rideshare acceptance
• Human factor involved technologies design in order to improve the user acceptance of pooled rideshare and increase transportation system energy efficiency
• Simulation and experimental validations and evaluations of improvements on user acceptance of pooled rideshare and energy saving impacts on transportation system
## Milestones

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• Go/No-Go Decision Point
Technical Approach
Approach

- Phase 1: Survey-based studies
- Phase 2: In-situ studies

**Human Factors Studies (Task 2)**
- Human factor barrier analysis
- PR user acceptance modeling

**Technologies Design (Task 3)**
- Human-Machine Interfaces
- Multi-mode Pooling and Repositioning Optimization
- Adaptive Routing

**Simulation and Experimental Validations with POLARIS (Task 4)**
- Global Positioning System
- Cellular Network
- Human-driven TNC Vehicle
- Automated TNC Vehicle
- POLARIS Transportation Simulation

**Pooled Rideshare Data Collection (Task 1)**
- Demographics
- PR acceptance model (static & dynamic)
- Vehicle factors:
  - HMI factors
  - Mode and repositioning factors
  - Routing factors
- Acceptance of this vehicle
Approach

**Task 1: Pooled rideshare (PR) data collection**
- Task 1.1 – Survey based human factors studies on PR
- Task 1.2 – In-situ human factors studies on PR

**Task 2: PR Human Factor Studies**
- Task 2.1. Analysis of Human Factor Barriers on Pooled Rideshare (PR)
- Task 2.2. Theoretical Modeling of User Acceptance on Pooled Rideshare

**Task 3: PR Technologies Design**
- Task 3.1. Human-Machine Interfaces (HMIs) for Improving User Acceptance of Pooled Rideshare
- Task 3.2. Multi-Mode Pooling and Repositioning Optimization for Improving User Acceptance of Pooled Rideshare
- Task 3.3. Adaptive Routing for Improving User Acceptance of Pooled Rideshare

**Task 4: Simulation and Experimental Validations**
- Task 4.1. Simulation and Human-and-Vehicle-in-the-Loop Pooled Rideshare Platform Development
- Task 4.2. Simulation and Experimental Validations on User Acceptance and Energy Savings
• The team submitted the Institutional Review Board (IRB) application at the start of the project.

• After receiving feedback from the IRB office at Clemson University, the application was modified and approved on February 8, 2021.

• Separate informational letters (consents) will be used for data collection by the Clemson team in the Greenville, SC area and the J.D. Power team for the national survey.
Survey-based Human Factors Study Design

Screener question: In the last 5 years, which of the following best describes your experience using a rideshare service (e.g., Uber, Lyft, Via, Wingz)?
Are you 18 years of age or older?

Consent

Ridden in one alone or with people I know
Ridden in one with people I did not know
Never been in one
Driver for a rideshare company

Section 1: Your transportation needs
Section 2: Willingness to consider
Section 5: Optimizing your experience
Section 6: Rideshare drivers

Section 3: If yes, would consider
Section 4: If no, would not consider

Section 7: Demographics

Current PR acceptance
(4 scale: Def. will not -> Def. will)

Importance of factors
(4 scale: NOT->Very important)

Qualitative Scenario Questions:
Will it improve PR acceptance if ....
(4 scale: strongly disagree -> strongly agree)

Quantitative Scenario Questions:
Will you accept PR if wait time/travel time/cost is ....
(4 scale: Def. will not -> Def. will)

Expected PR acceptance
If all factors are met, will you accept PR?
(4 scale: Def. will not -> Def. will)
Survey-based Human Factors Study Development

- Survey study development on computer and smartphone

In the last 5 years, which of the following best describes your experience using a rideshare service (e.g., Uber, Lyft, Via, Wingz)? Select all that apply.

A rideshare service is defined as being a passenger in someone else's private vehicle driven by its owner for a fee typically arranged by means of a website or app.

- Ridden in one alone or with people I know
- Ridden in one with people I did not know
- Driver for a rideshare company
- Never been in one
Survey-based Human Factors Study

• An iterative design process was used to develop the survey leveraging J.D. Power’s expertise. All team members were involved in the iterative process to ensure the results can facilitate the future stages of this work focusing on the development of PR models and technology design.

• Students in an Automotive Human Factors course at Clemson provided usability feedback on the survey as part of a class activity.

• A pilot study was conducted in Greenville, SC to ensure the metrics and data collection process work properly.
  • A convenience sample with 90 completed surveys was conducted the last week of April.
  • Data analysis and modeling checking will be completed before the national survey.

• The national survey will launch in July. July was selected due to President Biden’s goal of returning to normalcy in regards to the pandemic in order to reduce the bias on survey data caused by COVID-19.
Simulating Pooled Rideshare in POLARIS

- Heuristic PR strategy implemented in POLARIS.
- Trip matching using zone-based search.
- Dynamic matches occur en route.
- On-going trip and candidate trip request tested for similar directionality.
- Dropoffs reordered based on traveler’s instant delay.
  - PR option stopped if instant delay greater than predefined threshold.
- Framework exists to incorporate the proposed new PR technologies in the following work
Pooled Rideshare Experimental Platform

• Three vehicles are available for this project to develop human-driven and automated PR vehicles including
  • an electric vehicle Nissan LEAF (sedan)
  • a gasoline vehicle Mazda CX-7 (SUV)
  • a hybrid vehicle Chrysler Pacifica (minivan)

• These vehicles provide varieties in both powertrains (e.g., electric, gasoline, hybrid), vehicle size (e.g., sedan, SUV, minivan) and vehicle mode (e.g., human-driven, automated)

• The electric LEAF and gasoline CX-7 are being retrofitted by the team with automated actuation systems (including, steering actuation, throttle and brake actuation) and a suite of automated driving sensors
Hybrid Chrysler Pacifica retrofitted by AutonomousStuff and New Eagle
Responses to Previous Year Reviewers’ Comments

• This project started in October, 2020 and was not reviewed last year.
Collaboration and Coordination with Other Institutions

- **EEMS093 – POLARIS:** Behavior models
- **EEMS100 – Curb Allocation**
- **Pooled Rideshare Data Collection (Task 1)**
- **Human Factors Studies (Task 2):**
  - Human factor barrier analysis
  - PR user acceptance modeling
- **Technologies Design (Task 3):**
  - Human-Machine Interfaces
  - Multi-mode Pooling and Repositioning Optimization
  - Adaptive Routing
- **Simulation and Experimental Validations with POLARIS (Task 4):**
  - Global Positioning System
  - Cellular Network
  - Human-driven TNC Vehicle
  - Automated TNC Vehicle
  - POLARIS Transportation Simulation
- **EEMS093 – POLARIS:** Workflow
- **O’Hare Optimization FOA**

Institutions:
- Clemson University
- J.D. Power
- Ford
- UCI
- Argonne
- Pacific Northwest Laboratory
- Georgia Tech
- ITIC
Remaining Challenges and Barriers

• Require extensive amounts of human data to understand the factors which may affect user acceptance of pooled rideshare
• Require pooled rideshare user acceptance models to quantitatively model the relationship between vehicle technology factors and human acceptance
• Require new pooled rideshare technologies to incorporate human factors into the technologies design
• Require effective validation approaches to validate the desired pooled rideshare technologies and evaluate the energy impacts
• COVID-19 Pandemic Impacts: The pandemic may impact the human factors study results with bias. It may also cause some long-term impact in people’s acceptance of pooled rideshare.
Proposed Future Research

• **Pooled rideshare (PR) data collection (FY 2021)**
  • Deploy the designed survey nationally with a large sample size (5,000) national survey to collect data (focusing on large cities such as Atlanta, Austin, Chicago, Detroit, New York City and San Francisco)
  • Deploy the designed survey with a medium sample size (1,000) in Upstate South Carolina to collect data
  • Conduct in-situ human factors study in pooled rideshare

• **Pooled rideshare (PR) human factors studies**
  • Conduct analysis on PR data to understand factors which may affect PR acceptance and ways to improve PR acceptance (FY 2021)
  • Develop PR acceptance models to compute PR acceptance based vehicle factors and user demographics (FY 2021)

• **Pooled rideshare (PR) technologies design (FY 2022)**
  • Develop new HMIs, new multi-mode pooling and repositioning algorithms, and new adaptive routing algorithms based on the PR human factors and PR acceptance models

• **Simulation and experimental validations**
  • Implement the PR factors, PR acceptance models and designed technologies in POLARIS simulation and development a human-and-vehicle-in-the-loop pooled rideshare platform (FY 2021 and 2022)
  • Validate and evaluate the designed technologies in POLARIS simulation and the human-and-vehicle-in-the-loop pooled rideshare platform (FY 2023)

Any proposed future work is subject to change based on funding levels.
Summary

• **Approach**
  • Human factors studies to understand and model user acceptance of pooled rideshare
  • Develop new pooled rideshare technologies by incorporating human factors and acceptance models
  • Simulation and human and vehicle in the loop experimental validations with POLARIS

• **Technical Accomplishments**
  • Completed survey preparation and completed the survey design for comprehensively discovering factors which may affect user acceptance of pooled rideshare
  • Developed the online survey deployment on either a computer or a smartphone
  • Conducted a usability activity with students in an Automotive Human Factors course
  • Collected pilot data in the Upstate of South Carolina with 90 completed surveys
  • Developed and tested pooled rideshare modules in POLARIS
  • Developing pooled rideshare experimental platform for human and vehicle in the loop validations

• **Future work**
  • Collect data using the developed survey both nationally and in Upstate South Carolina
  • Analyze factors and develop pooled rideshare user acceptance models
  • Design new PR technologies based on the human factors and PR acceptance models
  • Validate the new PR technologies via both simulation and experiments

Any proposed future work is subject to change based on funding levels.
Survey-based Human Factors Study

KEY INFORMATION ABOUT THE RESEARCH STUDY
Dr. Johnell Brooks and Dr. Yunyi Jia are inviting you to volunteer for a research study. Drs. Brooks and Jia are faculty members in the department of Automotive Engineering at Clemson University’s International Center for Automotive Research (CU-ICAR). They are conducting the study, along with their students and researchers from J.D. Power.

- **Study Purpose:** The purpose of this research is to understand consumers’ preferences for various modes of transportation.
- **Voluntary Consent:** Participation is voluntary and the only alternative is to not participate. You will not be punished in any way if you decide not to be in the study or to stop taking part in the study.
- **Activities and Procedures:** Your part in the study will be to complete an online survey. If you are interested in participating in future studies, you can include your name and contact information at the end of the study.
- **Participation Time:** It will take you about 20 minutes to be in this study.
- **Risks and Discomforts:** We do not know of any risks or discomforts to you in this research study.
- **Possible Benefits:** You may not benefit directly from taking part in this study, however the information you share may help researchers and policy makers in the future.

INCLUSION REQUIREMENTS: You must be at least 18 years of age to participate.

PROTECTION OF PRIVACY AND CONFIDENTIALITY
The results of this study will be shared with the study sponsor, the US Department of Energy (DOE). The results of this study may be published in scientific journals, professional publications, or educational presentations. Individuals will not be able to be identified in any of the reports or publications shared with the DOE or in professional publications or presentations. Please complete the online survey in a private setting.

The information collected during the study could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from the participants or legally authorized representative. However, no identifiable private information will be shared with anyone outside of Clemson University’s research team. If you choose to provide your contact information for us to contact you about participating in future research studies at Clemson University, your contact information will only be shared with Clemson personnel.

CONTACT INFORMATION
If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or orb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC’s toll-free number, 866-297-3071. The Clemson IRB will not be able to answer some study-specific questions. However, you may contact the Clemson IRB if the research staff cannot be reached or if you wish to speak with someone other than the research staff.

If you have any study related questions or if any problems arise, please contact Dr. Johnell Brooks or Dr. Yunyi Jia at Clemson University at 864-252-7722.

CONSENT
By participating in this study, you indicate that you have read the information written above, been allowed to ask any questions, and you are voluntarily choosing to take part in this research. You do not give up any legal rights by taking part in this research study.

**Major categories of factors**
- Time
- Cost
- Environmental impact
- Personal safety
- Accessibility needs for passengers with disabilities
- Reliability
- Convenience