Simulation and Traffic Control Methodologies

Concept
- Connected / Automated vehicle technology with autonomous driving has the potential to allow intersections to be controlled without use of traffic signals or other control devices
- Numerous simulation studies of automated intersection control have been previously carried out
- Impact of non-motorized traffic on this type of operation has not been extensively explored
- This study seeks to investigate such impacts where automated traffic is interrupted to serve pedestrians

Simulation
- Cellular automata simulation was selected for this study
- Some Existing tools included the AIM software by UT-Austin, and a VISSIM plug-in available on OSAGP.
- These tools did not have built-in support to implement reaction to a pedestrian phase in service
- Instead, a cellular automata simulation was implemented using Processing, a Java-based programming environment

Control Algorithms Compared
- Fixed-Time (FT) Conventional Intersection Control
  - The duration and timing of each phase is predetermined and repeats on a fixed schedule
  - Signals are coordinated for one-way progression
- Fully-Actuated (FA) Conventional Intersection Control
  - Phases are extended as long as a detector is occupied (in this simulation, as long as a vehicle is present within 400 ft upstream of the stop bar) – up to a maximum green time
  - Pedestrians served at next vehicle phase time
  - No direct mechanism for coordination is used
- First-Come-First-Served (FCFS) Automated Intersection Control
  - At each decision time, the intersection considers all vehicles on all approaches and decides to serve whichever is the nearest vehicle within range
  - Possibility for feedback to vehicles on the selected / non-selected “phase” (not fully implemented)
  - Pedestrians served “immediately” (subject to some practical constraints)
  - Pseudocode for algorithm shown to the right
  - No direct mechanism for coordination is used

Impact of Pedestrian Call Frequency

- Total duration of time all vehicles spent completely stopped
- Delay increases as number of pedestrians increase (FA & FT)
- FT is constant because the vehicle phase times do not change
- FCFS has lower delay than FA for all scenarios
- FCFS stops performing better than FT around 50 peds per hour
- FA & FCFS delay start to come back down at high ped volumes, phase times become function of max times

Average Delay by Movement Type
- This plots the average delay experienced by vehicles on the side street versus the main street
- Closer to origin of graph is better
- Main street delay is lowest for fixed time because of ideal coordination
- FA and FCFS scenarios have much lower side-street delay
- FA does a little better than FCFS for the main street, but not side street
- Delay of both FA and FCFS increases with pedestrian volume

Trajectory Visualizations
- Fixed-Time
  - Other than random arrival at the first intersection, coordination is ideal
- FA, No Peds
  - Vehicles tend to stop at every intersection (no coordination); stop time is relatively brief
- FA, Heavy Peds
  - Vehicles usually stop at every intersection and the stop time tends to be long
- FCFS, No Peds
  - Vehicles usually stop at every intersection and the duration of stop is brief (compared to FA)
- FCFS, Heavy Peds
  - Vehicles usually stop at every intersection and the stop time is longer than FA with heavy peds

Conclusions
- An automated intersection control (AIC) algorithm was compared against two different conventional control methods – Fixed-time with highly idealized coordination, and fully-actuated (FA) control
- The AIC algorithm performed better than both methods of conventional control when no pedestrians were present
- As the number of pedestrians increased, the amount of delay increased for both AIC and FA control
- The AIC algorithm delay increased above FT control at around 50 pedestrians per hour

Future Work
- This was a preliminary study intended to explore the evolution of system performance
- Future work will seek to expand the study to a higher fidelity simulation environment, more realistic conditions, and more advanced AIC algorithms