Playing Chess With Cars

The purpose of this document is to understand how algorithms that are designed to play chess can assist Artificial Intelligent in guiding and perhaps fully controlling the cars that we drive today.

There are considered to be 6 levels of autonomous driving :

- **Level 0**
  - A typical, everyday car.
  - Driver performs all operations including steering, acceleration and braking
  - e.g. : an everyday car of a slightly older make

- **Level 1**
  - Driver handles most of the cars functions
  - Assistance comes in the form of :
    - brake boosts if coming too close to one vehicle
    - parking assistance with cameras and sensors to detect proximity
  - e.g. : most new cars have this level of automation

- **Level 2**
  - Partial automation enables drivers to disengage from some driving functions.
  - Assistance in the form of :
    - speed control to maintain proper distance between cars.
    - Centering the car in between the lanes
  - e.g. : Many are commercially available, like the 2019 Volvo S60

- **Level 3**
  - Conditional automation

- Cars are considered autonomous under ideal conditions and require no human intervention at speeds below 60 kmph.
- e.g. : Honda is planning to introduce some cars in the near future

- **Level 4**
  - High automation.
  - Able to monitor road conditions, respond to obstacles, determine when to turn and when to change lanes.
  - Activated only in ideal road conditions. Unable to negotiate traffic jams, or major obstacles.
  - e.g. : Google's Waymo Project

- **Level 5**
  - Requires no human interaction.
  - Vehicles are able to brake, steer, and accelerate while monitoring road conditions like traffic jams.

Vehicles will be driven using Artificial Intelligence (AI) and will respond to real-world data points, generated from sensors. The data generated can be as much as 4TB/hour. Considering such large amounts of data, it helps us if we visualize the scenario as a chess game.

The stakes involved in the game of driving are much higher than those of chess, often involving human lives. The AI and the assisting algorithms and sensors need to be highly polished.

Chess is an deceptively easy game. There are only a fixed amount of pieces, and there are well defined moves for every piece ,and a restricted space of 8x8 board. Though this is not the case for real world driving, we will see how this visualization helps.

Understanding chess playing is more than merely being able to play chess. The hope is that the more we understand chess, the more we understand how we think.

Driving as a chess game.

The pieces.

Different objects and cars can be modeled as different chess pieces.
e.g. : A car with changing lanes or turning can be seen as a rook, seeking to go diagonal, a truck as a queen, being able to go in any direction without any challenge from other cars or 'pieces'.

The Board

For the board, we can assume that the road is the board, with the lanes as rows. With each square the space that a car occupies including the space that should be around a car for safety.
The board is continuously moving, radiating out from our car.
The distance ahead that we can see(with onboard sensors) is our edge.

The distance we can see varies as the general condition varies.
And as we move, new pieces enter and exit our playing space.
So our game space is continuously changing, with varying number of pieces and a mercurial playing board.

The Goal

The goal is to minimize the time spent on traveling while maintaining a high level of safety of the driver and other cars.
So, in the ‘game’ of driving, while on a freeway, if a spot opens up, we will try to move into that spot, but if it is ‘guarded’ by other cars, then we’ll have to maneuver around them.
We had to calculate where the other “chess” pieces are (the cars and trucks around us), we had to gauge the openings available for a move, we then devised a series of tactical moves that would get us positioned to get into the desired opening.
Of course, just like in the game of chess, moves by the enemy can change the conditions and the original plan, driving also requires us to change our strategies in real time, often just a few seconds, to avoid disaster.

Win-Loose conditions
Although there are no clear win or loose statements in driving, we can estimate that us reaching our destination in a reasonable time limit is a win, BUT the safety of our car and of others takes a much higher priority than reaching on time.

Normally chess is a two player game, but driving chess is played by each and every person that you encounter on the road, with each one of them seeking to minimize his time spent traveling and (hopefully) maximizing safety of themselves and others.

So to realize the full complexity and sheer scale of this virtual game that we have created I reiterate :

Hundreds of other chess players, all seeking to “win” at their chess game (getting to their desired location as soon as possible and balanced by the safety factors of driving). Their chessboards are dynamically changing, doing so from moment to moment, just as ours is too, widening and shortening while driving.

To reduce the complexity, we can imagine the other cars as pieces being moved by a macro-player. All drivers are independent, but to reduce the complexity, we can assume them to be moved by a common player.

Here’s the usual steps involved in the AI driving task:

- Sensor data collection and interpretation
- Sensor fusion
- Virtual world model updating
- AI action planning
- Car controls command issuance

The first three steps are done sing various sensors that are on board the car. The object detection is done using ANN that have been trained to identify objects like car, buses, red-lights, etc. This has to be done in real-time and is very crucial.

In the fourth step is where the chess-like algorithms that we have discussed come into play. The AI has to take a look at the present state, and using the driving strategies and driving tactics, derive the actions that need to be taken next. The AI will then issue driving command controls to the self-driving car accordingly.

It cannot try to explore all possible ways in which to next move the self-driving car as the time constraints are much stricter than in chess.

The problems

- Human unpredictability.
  - We humans are emotional creatures, often doing irrational things, or making genuine mistakes, whatever the case, but the fact remains that humans often do not do the “right” thing when it comes to driving. Be it over speeding, wrong turns or not respecting the right of way.
- The absolutely massive scale at which we need to predict to make viable choices. It is too complex to be calculated on real-time, so is limited to very few factors surrounding the car.(actions of cars immediately surrounding us are considered, and not beyond that)
- non-ideal conditions that can disrupt the data collection or change other vital variables. (e.g. rain changing the stop distance)
- Time windows for decision making are very short and have severe penalties if violated.

Conclusion

These simplistic approaches are not going to get us to a true Level 5 AI self-driving car. They are only stopgaps on the way to getting there. If we stay with just those rudimentary approaches, there is little hope of achieving a true AI self-driving car.