

# Patent Analysis

## Unified Motion Planning Algorithm for Autonomous Driving Vehicle in Obstacle Avoidance Maneuver

US9457807B2

Ankit Aggarwal, Deepam Ameria, Bhaswanth Ayapilla, Simson D'Souza, Boxiang Fu

Team I  
Carnegie Mellon University

# Company Description

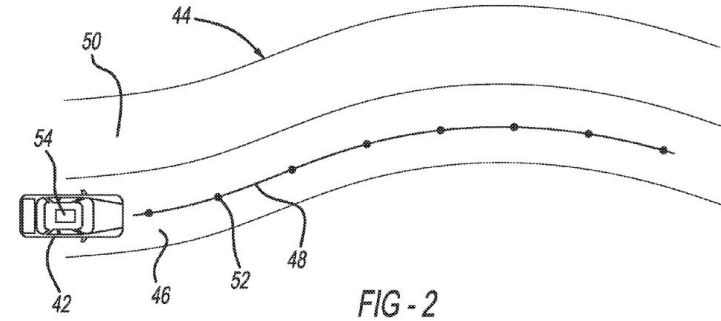
- **Name:** Moovita
- **Description:** Singapore based AV scale-up founded in 2016. Focuses on mobility solutions for urban environments.
- **Intention:** Hope to expand into the US market. Current software focuses on urban environments, lacking the capability to switch across multiple lanes of traffic nor navigate wide open highways in the US.
- **Strategy:** Acquire core US technology patents to enable the deployment of existing products in the US.



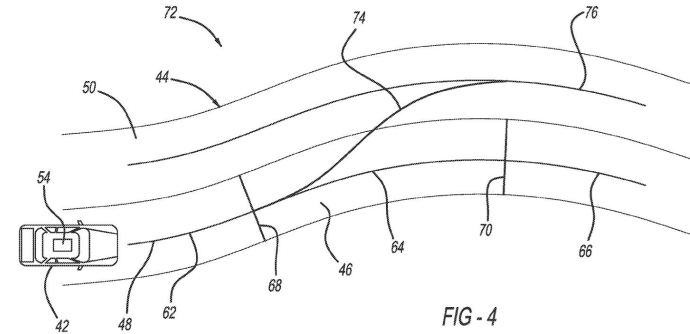
# Patent Description

- **Name:** Unified motion planning algorithm for autonomous driving vehicle in obstacle avoidance maneuver.
- **Patent Number:** US9457807B2
- **Abstract:** Method for path planning and trajectory generation for autonomous vehicles. Focuses on lane centering, lane changes, and obstacle avoidance.
- **Inventors:** Jin-woo Lee, Upali Priyantha Mudalige, Tianyu Gu, John M. Dolan
- **Assignees:** Carnegie Mellon University, GM Global Technology Operations LLC

## Lane Centering



## Lane Changing



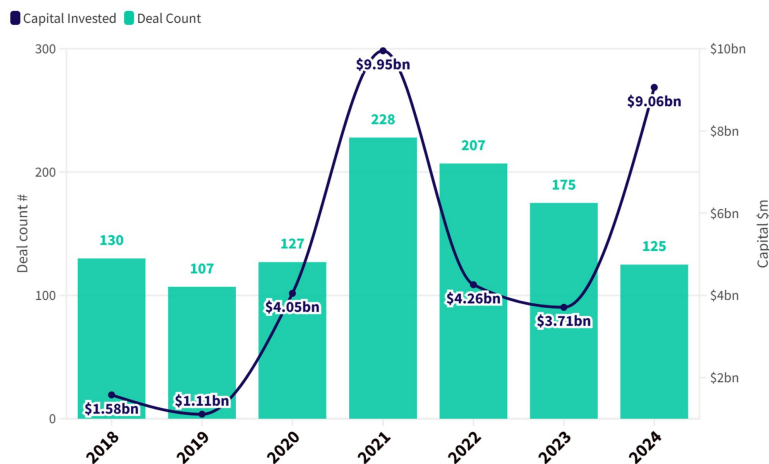
# Underlying Technology

- The patent is the culmination of several past academic papers, technical reports, and invention disclosures made by Prof. John Dolan's research group at CMU
- The core idea of the algorithm was **developed originally** and is a **real innovation** (the core papers have over 4000 citations combined) [[Source](#)]
- The patented technology was **marginally improved** iteration after iteration starting from the 2007 DARPA Urban Challenge until filing the patent application in 2014
- However, by the time the patent was filed, newer technologies (i.e. CNNs) were already introduced and becoming popular
- As such, it was patented so it formed a **patent fence** for GM, but was never integrated in their autonomous driving stack

# Overall Field

- Patent was filed during a time of increasing investment into the AV industry
- In recent years, the **field has seen declining investment** (albeit still billions) due to hard problem of making vehicles completely autonomous for all urban environments
- However, last year investments rebounded due to renewed investor interest
- The **field remains active**; however, the **number of players is shrinking** due to increasing consolidation due to high R&D costs

VC-backed rounds in autonomous driving tech 2018-24



Source: PitchBook

# Big Name Inventors

## John M. Dolan

- Professor at CMU
- Won DARPA Urban Grand Challenge in 2007
- 13,000+ citations in AV publications



## Jin-woo Lee

- Head of AD/ADAS group at Lucid Motors
- Ex-head of ADAS group at Hyundai Motors
- Developed SuperCruise for GM, Chevrolet & GMC



## Priyantha Mudalige

- Leads autonomous vehicle perception, planning and decision systems team at GM
- Over 100 patents and 60 publications in AV



## Tianyu Gu

- Sr. Engineering Manager at NVIDIA
- Implemented the patent's algorithms
- Over 1k+ citations in AV publications



# Patent Ownership

- Currently owned by **General Motors** (autonomous driving technology division)
- Technology transfer from CMU to General Motors
- Long-term collaboration with CMU and Prof. John Dolan (dating back to the 2007 DARPA Urban Challenge “Boss” vehicle)
- GM is generally **not interested in selling or licensing the patent**, especially for its autonomous driving technology
- This is because GM is developing autonomous driving in-house (Cruise subsidiary), and uses the IP as a “patent fence” against competitors



# Patent Expiry

- Patent **expires September 17th 2034**
- Broadly speaking, its expiry **will not impact the company's plans**
- This is because the autonomous driving technology has advanced significantly over the past 10 years
- Most autonomous path planning algorithms now use some form of CNNs, polynomial trajectory generation are now obsolete
- GM currently has phased out this algorithm in their autonomous navigation stack





# Other Patents

- Lots of other patents (72,000+) in the AV space
- The patent is **NOT a standalone patent** controlled by GM
- GM filed 81 AV related patents in Q3 2024, up from 57 in Q2 2024 [\[Source\]](#)
- GM acquired Cruise in Q1 2025, which has **1913 other patents** in the AV space, and 1707 in the US alone [\[Source\]](#)

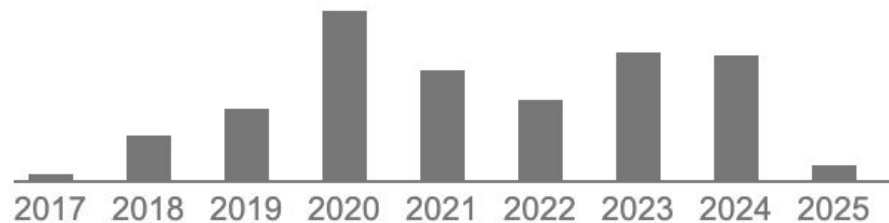
Table 1. Top 20 Most Cited Patent Holders by Other Patentees

#	Company Name	Number of Companies' Patents Cited by Others	Number of Citations Made by Others	Citation Ratio
1	Waymo	417	8,862	21.25
2	Cruise	349	3,218	9.22
3	Ford	423	2,880	6.81
4	Toyota	422	2,638	6.25
5	Zoox	111	1,387	12.50
6	Bosch	293	1,205	4.11
7	Porsche	273	1,103	4.04
8	Geely	147	1,096	7.46
9	Honda	147	948	6.45
10	Here Holding	49	898	18.33
11	Mobileye	121	886	7.32
12	Uber	143	857	5.99
13	Allstate Corp	43	840	19.53
14	Hyundai & Kia	184	788	4.28
15	State Farm	98	596	6.08
16	Continental	143	547	3.83
17	Denso	144	515	3.58
18	Nissan	90	457	5.08
19	Maplebear	9	445	49.44
20	State University System of Florida	3	429	143.00

# Patent Citations

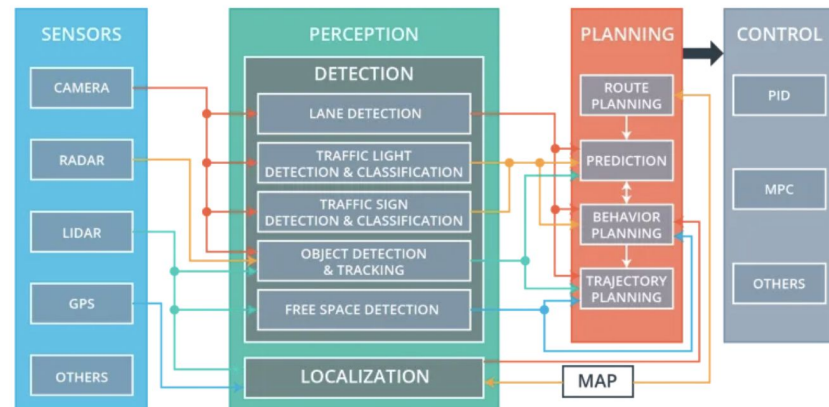
- **Patent Citations:** 183
- **Total Citations:** 248
- **High impact patent**, with citations from other AV companies such as Uber, Waymo, Ford, Toyota, Motional, TuSimple, Hyundai, etc
- However, number of citations is declining. State-of-the-art **CNN-based AV models do not cite this patent**
- Potentially indicates the **patent is relatively outdated** in the fast-paced AV technology space

Cited by 248



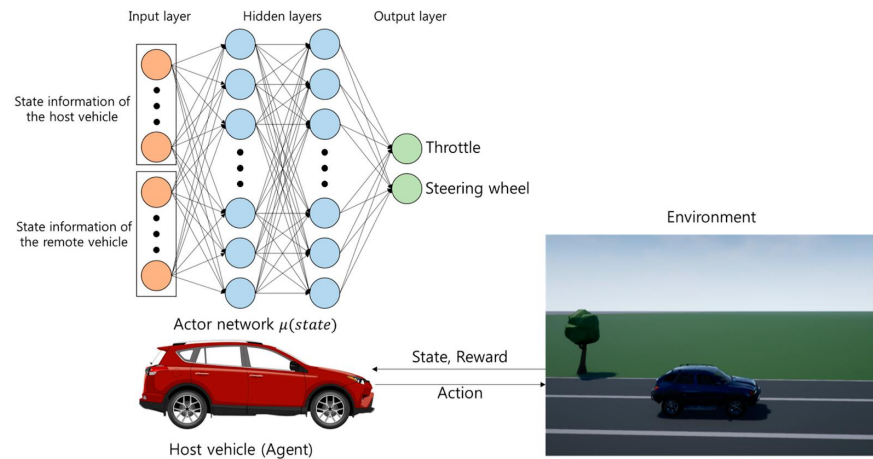
# Patent Claims

- The patent application was engineered to “**stake out as much of a territory as possible**” – Prof. John M. Dolan
- However, the **patent’s claim seems to be narrow**
- It describes **one specific method** for lane keeping or changing using a (fifth-order) polynomial trajectory
- The claim is **not fundamental** to the functionality of AV planning stack



# Engineering Around the Patent

- The patent can be **easily engineered around**
- Some possible workarounds that do not use a polynomial trajectory:
  - Spline-based trajectory from waypoints
  - RRT-methods for trajectory generation
  - Optimization-based planners
  - Occupancy-grid based trajectories
  - CNN-based end-to-end methods



# Competitive Analysis (Other Approaches)

Method	Core Idea	Pros	Cons
<b>Polynomial</b>	Fit a smooth curve based on boundary constraints	<ul style="list-style-type: none"><li>- Fast &amp; analytical</li><li>- Easy continuity constraints</li></ul>	<ul style="list-style-type: none"><li>- Hard to adapt dynamically</li><li>- Sensitive to boundary errors</li></ul>
<b>Spline</b>	Interpolate waypoints with smooth segments	<ul style="list-style-type: none"><li>- Smooth, tunable</li><li>- Local adjustments possible</li></ul>	<ul style="list-style-type: none"><li>- Global planning harder</li><li>- Can overshoot with tight curvature</li></ul>
<b>RRT</b>	Random or guided sampling	<ul style="list-style-type: none"><li>- Handles complex environments</li><li>- Good with dynamic obstacles</li></ul>	<ul style="list-style-type: none"><li>- Non-smooth paths</li><li>- Slower runtime</li></ul>
<b>Optimization</b>	Solve constrained optimization problem	<ul style="list-style-type: none"><li>- Handles dynamic models</li><li>- Rich constraints (speed, accel, etc.)</li></ul>	<ul style="list-style-type: none"><li>- Computationally expensive</li><li>- Requires tuning</li></ul>
<b>Occupancy Grid</b>	Plan based on reachable free space in a grid	<ul style="list-style-type: none"><li>- Obstacle-aware</li><li>- Real-time adaptability</li></ul>	<ul style="list-style-type: none"><li>- Discrete resolution</li><li>- Needs post-smoothing</li></ul>
<b>CNN</b>	End-to-end neural network	<ul style="list-style-type: none"><li>- No explicit path needed</li><li>- Adaptable, data-driven</li></ul>	<ul style="list-style-type: none"><li>- Computationally expensive</li><li>- Requires tuning</li></ul>

# Competitive Analysis (Significant Players)

Company	Strengths	Weaknesses	Opportunities	Threats
<b>Waymo</b>	<ul style="list-style-type: none"><li>- Safety record</li><li>- Owned by Google</li><li>- Real world product</li></ul>	<ul style="list-style-type: none"><li>- Vehicle is expensive</li><li>- Limited geographies</li><li>- Slow scale</li></ul>	<ul style="list-style-type: none"><li>- Expand robotaxi zones</li><li>- Licensing technology</li></ul>	<ul style="list-style-type: none"><li>- Tightening regulation</li><li>- Rising competition</li><li>- Trust erosion</li></ul>
<b>Cruise</b>	<ul style="list-style-type: none"><li>- GM backing</li><li>- Purpose-built vehicle</li></ul>	<ul style="list-style-type: none"><li>- Safety-related pause</li><li>- Public trust loss</li><li>- No active operations</li></ul>	<ul style="list-style-type: none"><li>- Relaunch with better safety</li><li>- Long-term GM fleet deployment</li></ul>	<ul style="list-style-type: none"><li>- Lawsuits</li><li>- Losing early mover lead</li></ul>
<b>Tesla</b>	<ul style="list-style-type: none"><li>- Huge data pipeline</li><li>- Scalable FSD updates</li><li>- Strong brand</li></ul>	<ul style="list-style-type: none"><li>- No LIDAR/radar</li><li>- No L4 approval</li><li>- Public beta controversy</li></ul>	<ul style="list-style-type: none"><li>- FSD licensing</li><li>- Consumer AV dominance</li></ul>	<ul style="list-style-type: none"><li>- Legal/regulatory risk</li><li>- Performance scrutiny</li><li>- Public distrust of Elon</li></ul>
<b>Aurora</b>	<ul style="list-style-type: none"><li>- Trucking AV stack</li><li>- Strategic partners</li></ul>	<ul style="list-style-type: none"><li>- Not commercial yet</li><li>- Low brand visibility</li></ul>	<ul style="list-style-type: none"><li>- Lead in L4 trucking</li><li>- Logistics automation boom</li></ul>	<ul style="list-style-type: none"><li>- Trucking union pushback</li><li>- Rising competition</li></ul>
<b>Zoox</b>	<ul style="list-style-type: none"><li>- Custom robotaxi stack</li><li>- Amazon integration</li></ul>	<ul style="list-style-type: none"><li>- No live service</li><li>- High R&amp;D costs</li><li>- Long time-to-market</li></ul>	<ul style="list-style-type: none"><li>- Urban AV disruption</li><li>- Logistics tie-in with Amazon</li></ul>	<ul style="list-style-type: none"><li>- Behind in road miles</li><li>- Safety unknowns</li></ul>

# Recommendations

- We as Moovita **should not pursue purchasing/licensing the patent**. We make this recommendation based on the following factors:
  - a. The patent **methodology is outdated**. Even GM does not use it in their autonomous driving stack
  - b. GM/Cruise is a competitor, and is likely **unwilling to sell/license** this patent
  - c. The technology is **easy to engineer around**, and has a variety of alternatives
  - d. The patent **scope is narrow**, and covers only a specific implementation rather than a foundational principle
  - e. The patent **expires in 2034** (9 years time)
  - f. The patent **cannot be used as a standalone**, it needs to be integrated to a broader AV stack. Significant investment is required to acquire other pieces of the stack

# Recommendations

- Instead, we should consider a **different strategic direction**:
  - a. **Reconsider entering into the US consumer AV market** as it is crowded and requires significant capital investment against juggernaut companies
  - b. Pursue niche markets in **controlled environments** (such as their current pilot program of autonomous buses in university campus environments)
  - c. **Focus on more state-of-the-art** AV solutions such as CNNs or **foundational patents**. However, be prepared to pay significantly for these patents
  - d. Try to **engineer around the technology** using a different approach
  - e. Try to **adapt and develop existing AV stack** used in Singapore for the US
  - f. **Cooperate with existing players** and license their entire AV stack



# Questions ?

# References

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