

Wyatt Newman¹ (Team Leader), Roger Quinn² (Co-P.I.), Michael Branicky¹, Frank Merat¹, and a team of over 60 faculty, graduate students, dedicated undergraduates, and industrial collaborators.

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Introduction

In 2007, Case Western Reserve University responded to DARPA's Urban Challenge to create a full-sized vehicle capable of autonomous operation through an urban environment, interacting with live traffic. Applications will include robotic military vehicles, future industrial, commercial and consumer vehicle automation and safety systems, and advanced controls for a variety of future intelligent systems.

Case assembled a core of industrial and alumni sponsors, an exceptional robotic vehicle, and a technical team of over 60 members, comprised of Case faculty and students and industrial collaborators. ENSCO, Inc. donated to Case its technical assistance and its advanced robotic vehicle, "DEXTER," which was a top performer in DARPA's previous Grand Challenge, the 2005 "Desert Challenge."

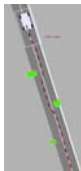
DEXTER finished among the top 20 teams, out of an initial field of 89 entrants. Only 11 teams were admitted into the finals.



Members of Team Case

Obstacle Avoidance

DEXTER can avoid obstacles in the current travel lane while staying within the lane boundaries and can even snake through a series of obstacles. Impassible obstacles are avoided by changing lanes



Intersection Awareness

Vehicles were required to determine safe operating procedures at intersections, with or without stop signs. In this picture, DEXTER is waiting for right-of-way at a four-way stop intersection.



Our Vehicle: DEXTER

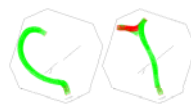
A high-performance autonomous vehicle

- Fully-autonomous operation
- 4-wheel drive
- Engine: GM 2L EcoTech
- Length: 160 inches
- Width: 84 inches
- Height: 56 inches
- Wheelbase: 120 inches
- Ground clearance: 17 inches
- Weight: 3200 lbs
- Top speed: 110 mph



Navigating Obstacle Fields

- DEXTER is capable of navigating through and parking in obstacle fields and parking lots.
- Upon encountering moving vehicles, he will tend to the right, giving way to the left.
- Rapid re-planning allows DEXTER to modify its trajectory to compensate for newly observed obstacles without the need to stop (left). The planning algorithm also handles choke points (below).



Bio-Inspired Robotics

DEXTER uses a distributed control system, where a high-level planner (Route Planner) determines what goal needs to be accomplished. Lower level modules determine and perform the actions necessary to complete the goal, while many modules regulate their output in accordance with sensory input. This technique is modeled after biological principles observed in various vertebrates and invertebrates

Behavior level functions generate specific trajectories for each behavior using sensor information. Behaviors are instantiated by higher level state machines called moods. The mood is determined by what current action needs to be performed in order to complete the higher level goal, ranging from u-turns to negotiating intersections. In the process of attaining this goal, behaviors are called to create the path for DEXTER.

Studies have shown certain animals can perform basic motor functions after brain connections have been severed. For example, cockroaches will walk until exhaustion without changing posture or gait after a lesion that disconnects higher brain regions from lower regions. DEXTER can perform in the same way. If one of DEXTER's higher level modules seizes, the lower levels will continue to operate.



Challenges: Driving in the City

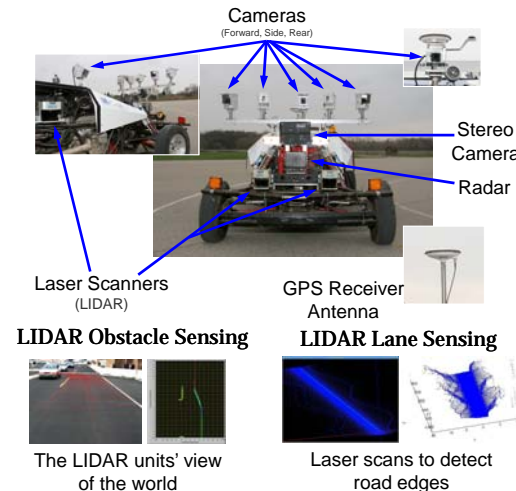
The Competition

- Complete multiple missions over a 60-mile course in under 6 hours
- Autonomously navigate city streets while following the rules-of-the-road and safe driving practices
- Complete missions by crossing checkpoints in a specified order
- Plan around obstructions and follow complex traffic patterns
- Safely interact with traffic vehicles and other automated robots

Test Areas A and B of the National Qualifying Event in Victorville, CA.



Sensors and Sensory Processing



Vision-Assisted Driving



Using five color cameras, as well as an infrared camera and downward-facing LIDAR unit, the Road Tracker creates an estimation of the road position and geometry. This estimation is merged with the *a priori* map information to create an accurate representation of the driving surface.

Creating Line Fits

- The Edge Crawler module identifies edges that are visible below the horizon that could potentially be the edge of the road surface
- Found edges are broken into line segments. An edge in (a) clearly turns following a curb. This is broken into separate segments.
- Lines are fitted to the segments. Some lines cut across the road and will be filtered in a later process



Sponsors and Support



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