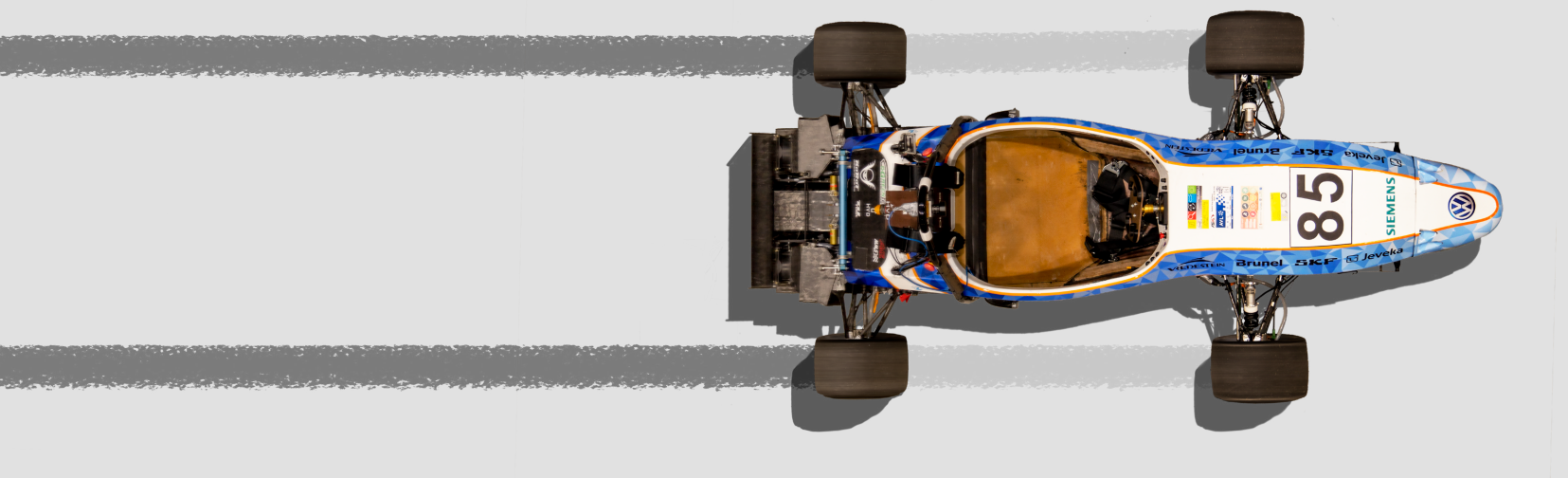
DRIVERLESS
MAGAZINE



"Hello world!\n"

DELFT DRIVERLESS
FORMULA STUDENT TEAM

MIT DRIVERLESS

1ST EDITION
DECEMBER 2018

Delft

Chief Engineer/ Team Manager
Rutger van den Berg

Operations
Bart Tromp
Sina Sen
Efe Kulaksizoglu
Ricardo Pagnan
Yannick Schulz
Tom Tom

Engineers
Chadi Salmi
Cyril Trap
Achin Agarwal
Yannick Schulz
Jeffrey Montagne
Rami Younis
Youri Blom
Bjorn Romijn
Anand Padmanabhan
Edward Neate
Thijs Raymakers
Yikai Zeng
Theo van der Zon
Mihail Ivanov
Titus Naber
Raj Kumar Muniyandi

Art Director/ Photographer
Yannick Schulz

MIT

Chief Engineer/ Team Captain
Luke Kulik

Team Manager
Shaurya Agarwal

Operations
Kevin Cheung
Andrew Foster
Camila Metello
Brendan Stiffle
James Fok

Engineers
Allen Wang
Adam Potter
Kieran Strobel
Mohammed Kabir
Finn Xu
Kathleen Brandes
Andrew Haeffner
Mengyuan Sun
Nick Stathas
Raphael Chang
Ravi Rahman
Bouke Edskes
Emily Zhang

WELCOME

Driverless transportation is inching slowly towards becoming a reality. We, as young aspiring engineers, are all fascinated by its future potential. To stay ahead of this autonomous curve, "Formula Student Team Delft" created a brand-new division this year: Driverless. Our mission at Driverless is quite simple: build the very best autonomous electric Formula-style race car that we can, and bring home the #1 prize at the competition in Germany coming summer.

Now who or what is Formula Student Team Delft exactly?
We are a student team comprised of students from the Technical University of Delft, and we have been designing, building and racing Formula-style race cars since 1999. Throughout the past 20 years, we have accomplished 9 victories in various international competitions. On top of that we have also secured a place in the world's top 10 Formula Student teams. For the first decade of our existence we built gasoline-powered race cars, but to stay ahead of the technological curve we switched to electrically-powered race cars in 2010. This year we have decided once again to switch things up. We are working on two projects with our now two divisions: "Electric" and Driverless.
The Electric division is building a completely new and improved electric race car, to get that extra bit of performance needed to beat the competition.
We from the Driverless division are working on the above-mentioned autonomous race car. We are converting the Electric division's previous (manned) race car with all the necessary sensors, actuators, computers and software to enable it to drive autonomously.

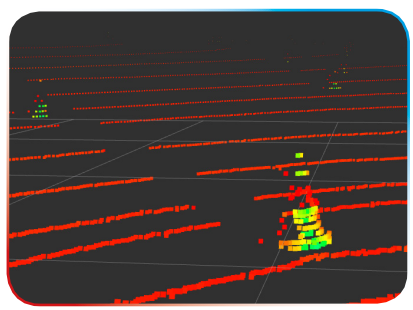
The Electric division has been around since 2010, and knows what they are doing very well.
In order for us from Driverless to keep up the high standards set by them, some excellent students were needed. This year our brand-new division is made up of 27 students from the TU Delft with various cultural and academic background. But building an autonomous car, especially for the very first time, is no easy task. So, in order to succeed we are collaborating with a student team from the Massachusetts Institute of Technology (MIT). Together we are excited to take on this challenge, and we hope you are just as excited to embark upon this journey with us..

THE DRIVERLESS CHALLENGE

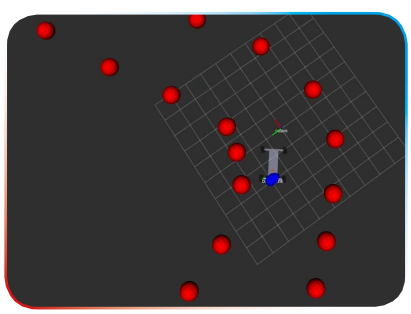
Luckily enough, we were given an existing and high-performing electric race car by the Electric division, and we can turn that autonomous. We don't have to also build the race car. Now if you might think that that means we are already about half way there... Well, then you should think again. There are a lot of engineering challenges left to tackle. Utilizing state of the art algorithms and techniques, following the given constraints from the Formula Student competition rules, and living up to the standards expected of us, leaves a lot of work left to be done. Here are some examples of the challenges we are tackling:

PERCEPTION

Good machine perception is highly dependent on data acquisition by "exteroceptive" sensors; these are sensors that perceive a machine's environment. The Driverless Formula Student competition has tracks laid out with blue and yellow traffic cones on either end. These cones provide the only reliable source for navigation for the race car. In order to sense both the position and color of the cones robustly, we use a combination of a camera and so called "LiDAR" sensor.



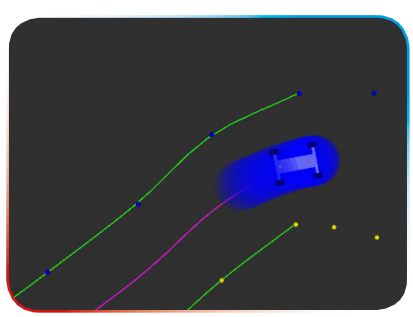
STATE ESTIMATION



Sensing the environment is one challenge. However, perception is only capable of position estimates relative to the car itself. Therefore, these readings need to be recorded to build a global map. In order to do that the autonomous system needs to know exactly where the vehicle is in the map at any given point in time. Algorithms which give a solution that achieve this Simultaneous Localization And Mapping are called SLAM. As we can see; engineers are very creative when it comes to naming things.

PATH PLANNING

At the Formula Student competition, the autonomous race car is put on a track laid out by blue and yellow cones, and it is not allowed to have any knowledge of the track prior to driving on it. Thus, planning the path that is to be taken is very important. One of the main challenges in the department responsible for this (the path planning department) is the understanding of the map. The path planning department will use the cone locations, obtained from state estimation, to estimate the boundaries of the track and plan a route within these boundaries that will result in the fastest track time, keeping the race car's performance capabilities in mind.



DELFT TEAM TRIPS

Team chemistry is arguably one of the most important aspects that leads a team to success. The more you get to know each other's strengths and weaknesses and the more you get along with one another; the faster and smoother everything will go. In order to establish stronger bonds, we have gone karting and a full-fletched team building weekend.

KARTING



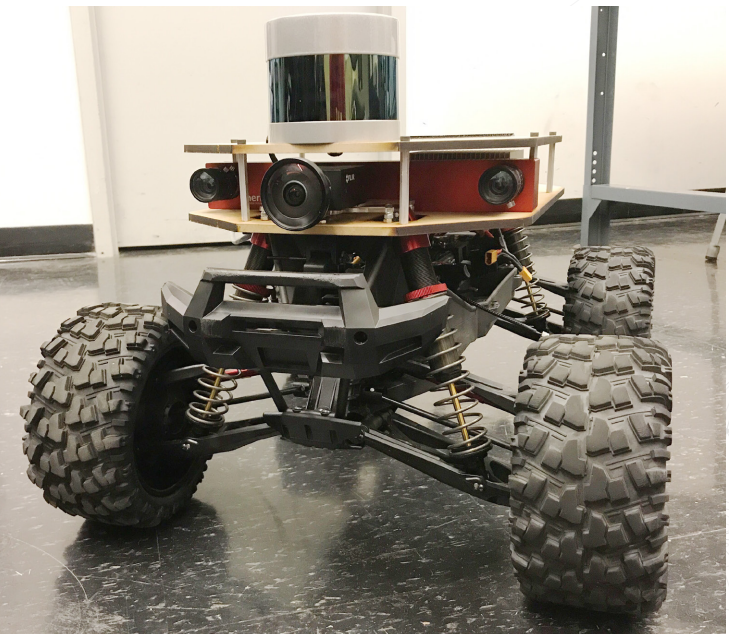
#	Kart	Driver	Fastest
1	39	Jeffrey Montagne	25.86
2	16	Rutger van den Berg	26.4
3	27	Cyril T	26.49
4	4	Chadi Salmi	26.87
5	3	Bjørn Romijn	26.91
6	47	Yannick Schulz	27.33
7	10	Edward Neate	28.91

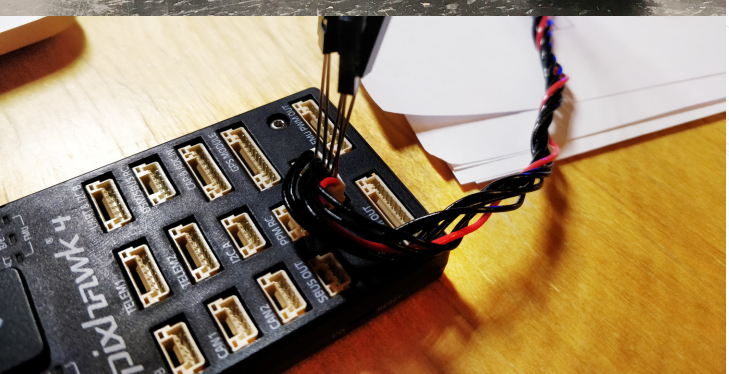
The kart outing is a true Formula Student Team Delft tradition. All team members get geared up and compete with each other in a racing challenge on the karting track. It provides an excellent opportunity to finally settle some bets on who is actually the fastest. The Electric division has always used it so see who the best drivers are for their car during the Formula Student competitions. Now obviously, we here at Driverless aren't looking for drivers... However, it is a fun activity and a great tradition to keep within the team.

TEAM WEEKEND



To further strengthen our bonds, a good few of the Driverless division went on a full weekend together. The weekend started off with dinner in the Dreamhall, where everyone feasted on some not-so-healthy Turkish food. Afterwards, we journeyed to our bungalow in Voorthuizen. Here our teambuilding truly began: a fun night full of great conversations, games.. and a few too many drinks. The next day, after a hearty breakfast, it was time to strengthen our friendly bonds by shooting arrows at each other -- archery tag! We did everything from firing in lines to an opposing team, to free-for-all and capture the flag. After this rather strenuous morning activity, the whole team needed some a rest and lunch. Later that afternoon, our aiming skills were put to the test once more with another fun activity: bowling. Some proved to be better throwers here than others. The night continued with a two-course meal, a pub quiz, and more board games. The next morning, we got to sleep in a bit, and after breakfast it was time to go back home.
A weekend like this is definitely a great catalyst in order to get to know one another.





TESTBED

A critical component of ensuring our success as a team is being able to rapidly test our progress, find gaps, and iterate quickly. Delft and MIT's geographic separation makes this even more difficult since only half the team is available to deploy the full car for testing. Our solution was to create the testbed - a 1/5 version of the full car with the same suite of sensors and software to mimic the car as closely as possible, allowing us to test on a daily basis if needed.

The base of the testbed is the Traxxas X-Maxx RC car. Of course, the X-Maxx is meant for casual fun and not to support a full array of sensors for autonomous driving. To attach our array of additional hardware including a short-range and stereo camera, LiDAR, and an onboard computer we water-jetted a a custom rig that is fixed on top of the testbed. The rig further allows us to design smaller casings for the individual components and attach them to the foundation. Lastly, we have modified the embedded controller in the car to allow us to send commands for fully autonomous control.

TECHNICAL UPDATE

EMBEDDED SYSTEMS

In the Embedded Software department, we do everything that is not directly related to making the car autonomous but is required for it to work. An example would be reading out sensors and passing this information around within the car. As well as code that monitors the state of the car, keeps track of inconsistencies and saves performance metrics for later analysis. Embedded Software provides a reliable environment for the autonomous software to operate in. Last month, for example, we were fixing some bugs that were present in the car from last year and we were also implementing some functionalities that eased testing days, such as the ability to make adjustments to all the settings in the car via the dashboard.

This will take the car's performance to the next level and help us to achieve our goals faster. During the testing days we gathered a lot of data sets for both LiDAR and computer vision. So we can start training neural networks and start validating algorithms on these data sets. Both are crucial for the car to drive on its own. A few days ago the embedded computer came in. We assembled it just this morning and we are now installing Ubuntu, that will be a major platform for all of the autonomous software to run on. Things are looking good right now and we hope to improve even more next month.

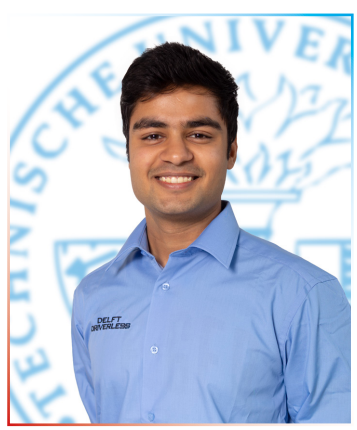
- Cyril Trap
Chief of Embedded Systems

PERCEPTION LIDAR

A typical LiDAR sensor (or Light Detection And Ranging) emits pulsed light waves from a laser into the environment and then calculates the time it took for the laser to bounce back which is then used to obtain really precise location of an object. It also returns the reflective intensity value of the surface. We use LiDAR as part of our redundant perception pipeline to estimate the color and the position of the cones. The point clouds obtained from the LiDAR are first corrected for motion of the vehicle and then passed onto the ground removal algorithm. The point cloud then undergoes a clustering step to isolate objects which are then passed through a filter that classifies an object as a "cone" or "not-cone".

After the classification, color of the cone is estimated using a classifier on the reflective intensity values obtained from blue and yellow cones.

For the past months, we have been working on obtaining a reliable real time cone detection algorithm. To test the reliability of our algorithms, we first test it on simulation followed by the RC testbed and then the actual vehicle. Our aim for the coming month is to further optimize the cone detection algorithm and get the color estimation module working.



- Achin Agarwal
Chief of Perception LiDAR

SPONSORS