TCS' Autonomy Framework—Autoscape

CIMdata Commentary

Key takeaways:

- *Autonomous vehicle development is a complex system-of-systems problem to solve but will have large societal impacts on many of our day-to-day activities.*
- *Competitive pressures and autonomous technology complexity are driving manufacturers to transform their development strategy, processes, and toolsets.*
- *Technology will play a key role in defining the future of business, customer experiences, and product or service behaviors of the agile automotive enterprise.*
- *By leveraging its manufacturing and automotive experience as well as its Neural Automotive Framework, TCS has launched Autoscape™—a comprehensive suite of solutions and services to help customers accelerate their autonomous vehicle development.*

Autonomous transportation, while a difficult problem to solve, has the potential to significantly impact not only on our day-to-day activities but also may have big societal impacts. There are many dimensions related to solving this problem including big data, many complex models, and the number of use cases required with an extreme risk profile. The complexity of moving a large, heavy product through streets with living and moving objects requires an enormous amount of testing to validate that the solution will work as designed.[1]

This system-of-systems problem is perhaps as complex as anything ever attempted by humanity. The safety implications are huge, even though automation almost always works better than manual processes, the accidents that do happen with autonomous technology will cause outcry. To succeed, autonomous technology and especially autonomous vehicles must launch virtually accident free. This is a tall order, well beyond the difficult to achieve six-sigma quality level. The resulting systems will also be upgraded in the field, requiring validation to continue even after mass production, to assure robust operations.

The benefits of a functional autonomous solution are huge - whether in driving or autonomous equipment operation, labor and effort will be reduced, improving safety and efficiency significantly. People will be able to make more productive use of their valuable time in the vehicle and as vehicle communication with infrastructure and each other, further efficiencies will be achieved such as improved traffic flow and the mitigation of accidents.

Another interesting opportunity is the ability to reduce the need to own a car, providing mobility solutions without having the labor cost of a driver. This will reduce the number of vehicles needed and maximize asset utilization. Think about how many cars sit idle in parking spaces and garages, and the waste space from all the parking areas in town centers. The vehicles can be stored away from the busy centers and summoned when required, which would mean that car parks can be repurposed for more beneficial uses for the community.

While the automotive and trucking industries get the most attention, autonomy is much broader. It is being used today in mining, manufacturing, and agriculture and solutions are being developed for recreational vehicles such as golf carts, last mile logistics, and even smart cities and infrastructure. While the applications are diverse, all them have similar needs and required capabilities to get functional, cost effective, and safe products to market.

[1] Research for this commentary was partially supported by TCS

Capabilities Required

To develop an autonomous solution many capabilities are required. The vehicle needs to make decisions based on the performance, operating environment, and objectives (e.g., what is the destination). Sensors are needed to measure position (i.e., GPS), velocity, acceleration, and assess the environment using radar, LiDAR, video, and audio. The data from these sources needs to be synthesized and processed quickly to control the vehicle. The ability to communicate with the infrastructure as well as with other vehicles in a nearby vicinity will further improve the solution.

The data captured during operation is large and complex, containing many data points per second. Data from different sources that needs to be normalized and harmonized so it can be consolidated into a clear view of the current state and forecast of the immediate future state (e.g., will that car ahead be in the way in a few seconds or not). Much of this processing needs to happen locally but may be augmented by cloud data, routing and traffic services, and fleet processing.

While the operating scenario described above is complex, the development capabilities needed to support it are even more complex. A digital twin of the product is a core requirement. Models representing the systems within the product and able to quantify behavior are the heart of the development environment. An autonomous environment goes far beyond a classical simulation environment. The dynamic behavior driven by steering, braking, and acceleration inputs modeled by classical simulation is only one of the models necessary to develop an autonomous solution.

The real work in autonomous is developing and validating the control algorithms and systems to ensure they function as designed, and all unique scenarios have been accounted for within the validation process. While physical testing is required and critical, it is not possible to physically test for all possible scenarios in most environments where autonomous products operate. Validation needs to happen both to ensure product safety and performance as well as meet regulatory requirements, and virtual validation is becoming an acceptable approach.

Often validation is quoted in number of miles driven, this is not the correct approach. The approach needed is number of scenarios or test cases covered and how complete the scenarios cover the scope of the operational design domain (ODD). Many scenarios need to be run to cover typical driving and many more are needed to cover the edge cases. As one considers the unknown combination of factors which could cause failed operation, the possible number of scenarios and test cases are in the scale of billions.

While automated and virtual testing is common in software products, they become much more difficult once the real world is used as an input. For example, if a dog runs in front of a car can it stop? What if the road is wet, icy, or covered in leaves? Does the vehicle stop or swerve? What if the street is narrow? Each scenario will have many different test cases. Defining the scenarios and test cases manually is not realistic; automation is needed.

Autonomous development is best supported by a platform approach. Capabilities are organized into an environment that enables collaboration across the product lifecycle. Key elements of such a platform include data gathering and management for IoT data, data curation to organize and tag the data so it can be consumed by algorithms, and an ALM environment to manage the algorithm, software, and scenario development. Validation is needed to execute the scenarios using real and synthetic data on virtual models to confirm performance. As the product matures and physical sensors and other product hardware become available, they need to be brought into the loop.

The agile process is the go to choice for autonomous development. The 5 level Advanced Driver-Assistance Systems (ADAS) maturity scale from 0—no automation to 5—full automation provides a solid framework to manage an autonomous development program. As the development program progresses and working software and systems are produced, they can be validated using DevOps concepts. This way product developers get quick feedback and capabilities can be incrementally improved via algorithm enhancement and software advances.

TCS' Approach

CIMdata has written a lot[2] about TCS and their deep technical capabilities. One of the exciting strategies they pursue is known as Neural Manufacturing.[3] They created Neural Automotive by applying this framework to the automotive industry where neural traits of "sense—perceive—act" will be crucial not only as an integral part of products and services but also during product development cycles.

TCS has extensive experience in solving complex problems in a range of areas including infrastructure, analytics, agile, automation (AI/ML), and automotive engineering. Unlike many system integrators TCS also has engineering teams with skillsets across all the domains necessary to develop autonomous products. TCS recently launched its Autoscape™ suite of solutions to help customers accelerate their Autonomous and Connected Programs. The Autoscape suite of solutions contains platforms and services that TCS has productized to support autonomy and is shown in Figure 1.

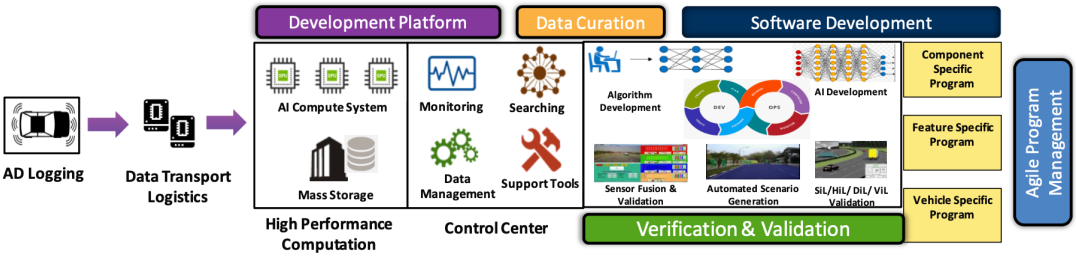

Figure 1—TCS' Autoscape Solution Architecture

Autoscape's end-to-end approach connects the hardware development platform, data curation, software development, and verification & validation pipeline with agile program management. Autoscape Data Services solutions help customers set up the infrastructure (compute/storage) needed to transport and manage the large volume of data from data loggers and other data sources as well as solutions to optimize, ingest, and manage data lake infrastructure on-premise, in the cloud, or using a hybrid. It also includes search capabilities that enable easy selection of data of interest and support synthetic data generation to fill in gaps in scenarios.

Data captured from sensors and cameras needs to be tagged and curated to train algorithms and validate solutions. TCS launched the Autoscape—Data Annotation Studio platform to address these requirements. It is a configurable, open framework that enables users to generate high quality annotations at scale with a high degree of automation. Customers can integrate their choice of annotation visualization tools if needed. The annotation engine features a custom training and inferencing capability to leverage specialized models in the annotation pipeline.

[2] https://www.cimdata.com/en/resources/solution-provider-profiles/plm-dossier-tata-consultancy-services

[3] https://www.tcs.com/content/dam/tcs/pdf/Industries/manufacturing/abstract/neural-manufacturing-covid-19.pdf

The software development environment for Autonomous Driving (AD) and ADAS work has evolved over the last 10 years. While the AD software development is critical, validation in both real and virtual worlds is where the rubber meets the road. The validation element of the Autoscape suite is branded as SIMPLE and is focused on providing simulation-based validation. It is a behavior-based, coverage driven solution that uses scenarios to validate product behavior. The scenarios are based on OpenSCENARIO 1.0.0 and can be executed across multiple simulation engines to test particular areas of interest. SIMPLE's Cognitive Engine utilizes AI to identify the interactions with scene elements including the environment, vehicle, traffic, and sensors to identify edge cases. The execution of the test suite is automated by the simulation engine and as SIMPLE is simulation engine agnostic it can easily integrate with multiple engines via the open API framework. SIMPLE also includes a library of scenarios that can be utilized to help kickstart a validation program.

TCS' solution is open which is critical when technology is moving fast. The ability to use current toolchains and leverage Autoscape capabilities when needed makes adoption easier. And, if an internally developed or best of breed solution is needed, it can be integrated. Openness is a critical characteristic of the platform approach and CIMdata sees Autoscape's openness as a big benefit to customers.

TCS worked with a US based automotive OEM to support their autonomous development initiative, leveraging TCS capabilities in the connected and autonomous space. Their focus was on building a data platform to manage huge volumes of data, provide decision analytics, and make the right data available to product developers. The OEM was able to speed time to market by leveraging agile, develop automation that improved productivity, use templates that standardized data management, and enable monitoring to track traceability, a critical process to support compliance. Another US based OEM is currently working with TCS leveraging TCS Autoscape Data Management and Data Annotation Studio to curate and annotate autonomous data at scale.

Conclusion

Autonomous products are becoming mainstream and are having an impact on consumers today with automotive early adopters. Autonomy goes far beyond self-driving cars and can be applied across many industries and domains including transportation, agriculture, manufacturing, recreation, and smart infrastructure. As it becomes prevalent in those areas it will have big impacts on society. Before autonomous products can be released to the public, they need to be proven safe and meet many requirements—not a trivial task.

TCS Autoscape, based on TCS' Neural framework is a holistic development platform for creating autonomous products. It includes advanced capabilities for managing large scale data pipelines, data curation solutions, and a toolchain to accelerate simulation led validation with real and synthetic data for safe deployment of autonomy capabilities. This capability to assess autonomous systems robustness within a chaotic operational environment is needed to achieve passenger safety. CIMdata is impressed with the scope Autoscape covers and the available customer case studies show how it can be applied to effectively solve real world issues and get safe functional products into production. Companies developing autonomous products should review Autoscape and discuss their needs with TCS.

About CIMdata

CIMdata, an independent worldwide firm, provides strategic management consulting to maximize an enterprise's ability to design, deliver, and support innovative products and

services through the identification and implementation of appropriate digital initiatives. Since its founding over thirty-five years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on a broad set of product lifecycle management (PLM) solutions and the digital transformation they enable. CIMdata also offers research, subscription services, publications, and education through certificate programs and international conferences. To learn more about CIMdata's services, visit our website at http://www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0) 495.533.666.