

# Engineers' Forum

Volume 36 | Number 1 | February 2015



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## Letter From the Editor

Hello Hokies!

Glad to see everyone back and busy! This semester the Engineers' Forum takes a look at what's new and noteworthy, and our goal is to bring the future to you!

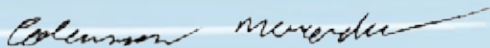
Each new semester presents a fresh round of challenges, possibilities, and opportunities for making new connections and achievements within our community. Our goal is to build upon the family that we call the Hokie Nation. Whether you're on the road abroad, in the feverish process of research, preparing a lecture, or still trying to understand the last lesson your professor gave you, perhaps now is a good time to sit back and enjoy our newest issue of the Engineers' Forum Magazine over a warm cup of coffee!

In this issue we feature articles about some of the best faculty and projects around. Take a look into the life and legacy of the famous Dr. Torgerson with Eileen's article about the theory of organization and the project being constructed in honor of one of our most loved faculty members.

Are you a tech nerd? Well we certainly are, and if you like futuristic vehicles check out Kristine's article about autonomous cars and their possible awesome applications! How would you like to predict the future of weather? Read up on C.A.M.'s article about the power of VT's weather modeling capabilities and the journey of Vt's very own Weather Research and Forecasting model.

If you haven't checked out our Ware Lab yet, get a taste of what it's like with Miles' column about the development and evolution of this multi-team center of projects from all areas of engineering! We also have a new entry in science fiction from Vidya, and a look into business models from Robel. As always, please comment or let us know how to improve; we love hearing back from our readers and hope you enjoy this month's publication!

Sincerely,



Coleman Merenda  
Editor-In-Chief

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# Virginia Tech's New Weather Model Poised to Shine

By C. A. M. Gerlach a Sophomore in Meteorology and Physics

Photo: C.A.M. Gerlach/Engineers Forum

Computational Scientist Dr. James McClure (second from right) and system administrators Tim Rhodes, Brandon Booker, and Chris Snapp, all with Virginia Tech's Advanced Research Computing (ARC) unit. Dr. McClure helped install and optimize the WRF weather model running on ARC's Blue Ridge supercomputer, and the system administrators are vital in keeping it running smoothly at peak performance.

A major power company in Virginia has inquired about Virginia Tech's weather modeling capabilities following the inception of the university's fast-growing meteorology degree program in 2011. "They asked us if we had fine resolution output to look at what they might be able to see in terms of forecasts from hurricane events and how that might help aid their planning in mitigating power outages," Dr. Andrew Ellis, associate professor of meteorology and climate science commented. "At the time, we had to tell them that we did not." However, Dr. Ellis and his colleagues in the Department of Geography, as well as the university's Advanced Research Computing (ARC) unit, weren't content to settle for that status quo. As Virginia Tech's very own deployment of the widely-used Weather Research and Forecasting (WRF) model stands poised to come online in the near future, that answer may soon be a confident "yes."

While the initial contact with the power company helped spark the effort to get the model operational on Virginia Tech's supercomputers, Dr. Ellis, along with fellow meteorology faculty member David Carroll, had the general



Photo: C.A.M. Gerlach/Engineers Forum

Computing and cooling equipment operated by Virginia Tech's Advanced Research Computing (ARC) unit. ARC runs the WRF weather model on the Blue Ridge supercomputer in cooperation with the Department of Geography.

idea in mind since Virginia Tech's meteorology program began. Given the latter's strong focus on spatial analysis skills and proficiency in Geographic Information Systems (GIS), both vital for success in today's world, operating the WRF was a natural fit. Not only would a Virginia Tech-run model serve as a vital resource for both researchers and operational weather forecasters around the region, but it would also allow students to gain hands-on experience with a critical tool that is increasingly ubiquitous in a wide range of meteorology-related careers.

A key goal of the project was to broaden the appeal and utility of Virginia Tech's WRF installation beyond just the



Photo: C.A.M. Gerlach/Engineers Forum

Brandon Booker, a system administrator with Virginia Tech's Advanced Research Computing (ARC) division, demonstrates one of the Blue Ridge supercomputer's 408 processing nodes. The WRF weather model runs in just under an hour on 48 of these 16-processor-core units.

university itself. "Our department met with both National Weather Service and HPC (Hydrometeorological Prediction Center, now renamed Weather Prediction Center) representatives a couple of years ago and discussed running a weather forecast model utilizing the supercomputer facilities on campus," Carroll said. "During that meeting it became clear that it would be a beneficial relationship." Dr. Laurence W. Carstensen, the Geography Department chair, then made the necessary contacts with the ARC to secure serious supercomputing power necessary for the project. Carstensen describes this high performance computing capability as a "major advantage" of Virginia Tech's model.

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Following those initial contacts, ARC computational scientist Dr. James McClure installed the WRF on Blue Ridge, the university's newest and most powerful computing cluster. Blue Ridge first came online in early 2013 and debuted at No. 402 on the Top500 list of the world's fastest supercomputers. After further enhancement and capacity expansions, the Cray CS-300 cluster now boasts a total of 6,528 cores and 27.3 terabytes of total memory, currently used by approximately 100 individual projects in fields from bioinformatics to fluid mechanics. Though a few climate models have been operated on an experimental basis in the past, running a fully-fledged operational forecast model, with its unique requirements and challenges, is a first for the machine.

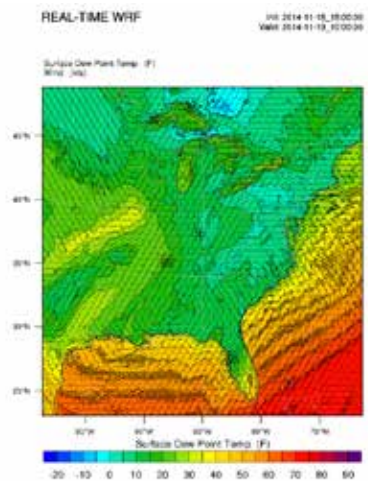
To make a forecast, the starting point for any weather model is a dataset describing the current atmospheric conditions across the model's domain. In this respect, "the WRF is very flexible in the types of data it can ingest — sea surface temperatures, surface observations and almost any other weather model output can be used to by the WRF to start its calculations," said Sean Ridge, a senior meteorology major. Ridge played a key role in helping to set up, test and prepare the model for operational use.

Then, the "big-iron computing part," as Dr. McClure calls it, is performed on the main processing nodes of Blue Ridge. This requires solving multiple partial differential equations at each of nearly one million grid points, each with 48 vertical levels, once every one to four minutes (depending on the configuration) for thirty hours. The 80 gigabytes of resulting output is then pushed back out to the file system, where post-process scripts are run on the data. Finally, visualization software is employed to transform the raw numbers into useful graphics depicting the weather variables of interest such as pressure, temperature and precipitation.

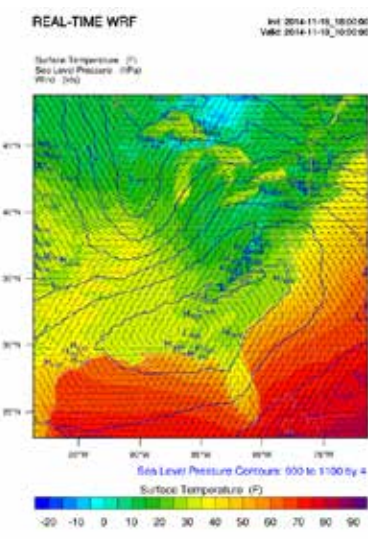
Due to the modular nature of Blue Ridge's software, the basic environment was already in place to get the WRF up and running. While it took "about a month" for setup and initial testing to complete, Dr. McClure stresses that only a small portion of this time was consumed with the actual installation. "The biggest part of what we do is optimizing the [model] so the performance is as high as possible," Dr. McClure explained. "That is really the name of the game in high performance computing after all."

As Dr. Ellis detailed, the optimization effort more than paid off: "In terms of ARC, one of the biggest contributions was the sheer speed at which the model can run." The Blacksburg National Weather Service office employs a simpler WRF over a small, local domain that takes over five hours to run on their machine. In comparison, Virginia Tech's WRF on Blue Ridge models a much more comprehensive area at a high resolution, covering most of the eastern United States, all in under an hour – and using less than a tenth of the cluster's capacity. This allows forecasters to make use of the output while it is still relevant, rather than many hours old.

The model is now in an "early-production-ready" state, undergoing final optimization tweaks and ensuring that the



OUTPUT FROM WRF V5.8 MODEL  
WF = 481, SW = 862, Levels = 30, Cn = 3cm, Phys Opt = 3, PMS Opt = 1, Cu Opt = 0



OUTPUT FROM WRF V5.8 MODEL  
WF = 540, SW = 868, Levels = 30, Cn = 3cm, Phys Opt = 3, PMS Opt = 1, Cu Opt = 0

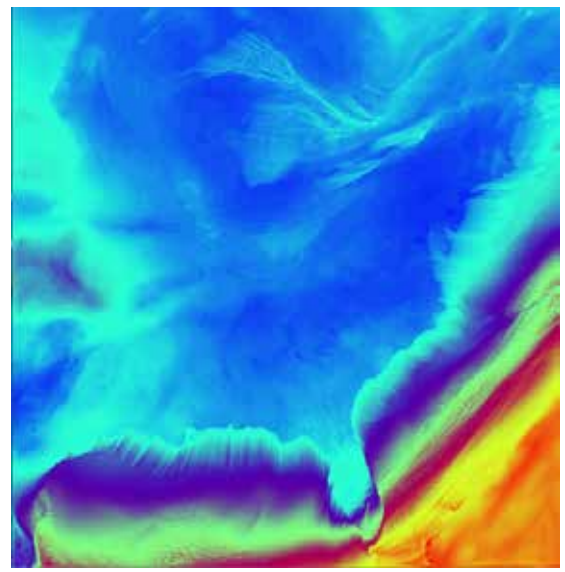




Photo: C.A.M. Gerlach/Engineers Forum

Dr. Andrew Ellis, Associate Professor of Meteorology and Climate Science in Virginia Tech's Geography department, is the faculty lead on WRF weather model project.

graphics and visualization scripts are ready for operational use. The plan is for the WRF to run two to four times per day at standard times, dependent on what can be worked out with the ARC. Once it is running regularly, the model's graphics will be distributed publicly on the web sometime "in the first half of spring semester," according to Dr. Ellis.

The numerous exciting planned and potential uses for the model data, benefits it can provide to the Virginia Tech community as well as outside parties, and possible future



Photo: C.A.M. Gerlach/Engineers Forum

Chris Snapp, a system administrator with Virginia Tech's Advanced Research Computing (ARC) unit, checks on one of the Blue Ridge super-computer's storage drive bays. These fast disks are used to store the enormous datasets, tens to hundreds of gigabytes in size, that the WRF weather model uses as input and output for its computations.

developments of the WRF programs will all be highlighted in a future issue of Engineer's Forum. For now, only one key element remains missing as far as Dr. Andrew Ellis is concerned:

"We need a catchy name for our WRF, if anybody has good ideas..."

An advertisement for the MACH37 Cyber Accelerator program. The background is a light gray with a faint illustration of a rocket launching from a launch pad. The text is in a bold, orange, sans-serif font. At the top, it says "MACH37™ CYBER ACCELERATOR". Below that, in a larger font, it says "WE LAUNCH NEW CYBERSECURITY COMPANIES". At the bottom left is the MACH37 logo, which consists of three upward-pointing arrows in orange and yellow. At the bottom right is the CIT logo, which consists of a stylized 'C' and 'I' in gray. The text at the bottom reads: "MACH37 IS AN INTENSIVE 90-DAY PROGRAM CREATED TO LAUNCH CYBER STARTUPS VISIT [WWW.MACH37.COM](http://WWW.MACH37.COM) FOR MORE DETAILS".

# A Front Row Seat to Theory of Organization

By Eileen Lacaden, a Senior in Industrial and Systems Engineering



If you walked by Pamplin room 30 every Monday, Wednesday and Friday during this past fall semester, you may have noticed several engineering students participating in a class called Theory of Organization. “Theory of org,” as students like to call it, is a leadership class comprised of mostly industrial and systems and mechanical engineers.

Dr. Paul Torgersen taught Theory of Organization here at Virginia Tech for 47 years up until his retirement following the spring semester of 2014. The course is now taught by Dr. Brian Kleiner, Director of the Myers-Lawson School of Construction. He previously assisted Dr. Torgersen in teach-

ing the course in recent years.

Dr. Kleiner is currently heading a “legacy project” in honor of Dr. Torgersen, who served Virginia Tech in various roles including president and professor. The project is a multimedia archive and book containing letters and memories from his past students and colleagues. Dr. Kleiner hopes to use the book as a textbook for the course in the future.

So what makes theory of organization so special? Why are engineering students lining up to take this class? Dr. Torgersen himself sat in on lectures last semester whenever the opportunity permitted itself. Although he is officially

Dr. Paul Torgersen (left) taught Theory of Organization for 47 years until Dr. Brian Kleiner (right) took over this past fall following Dr. Torgersen’s retirement.



retired, he was present in class and even gave a couple of lectures himself to share his experiences as a leader. Students were excited to see Dr. Torgersen continuing to do what he loves: teaching.

When Dr. Kleiner assumed the role of theory of organization professor, some different approaches were introduced to the class. One example was the introduction of the online program called LectureTools. The program allowed Dr. Kleiner to post presentation slides online, and then have students log into the lecture where they would respond to questions and polls within the slide set. It proved a great way for students to learn key points and to see what the rest of the class was thinking during discussions.

Topics ranging from opportunism and incentives to ethics and leadership styles were taught in the class this past semester. These topics were supported by case studies from the real-life experiences of Dr. Kleiner, Dr. Torgersen



President Sands answers students' questions about his hopes and plans for Virginia Tech's future.

and other professionals in the field. There were a number of guest speakers in the class, including Virginia Tech's president Dr. Timothy Sands, who had a question and answer session with the class. In addition to these case studies, the class also discussed current events, especially events on the Virginia Tech campus, and related these events back to the course material. These discussions kept the class well-informed and inspired more individuals to participate.

The final course project was for randomly-assigned groups of students to create video presentations. These presentations related back to the topics being covered in class and were held one day a week throughout the semester. At the end of the semester, the class voted on the videos they thought were the best. The videos allowed the students to explore digital media, and to learn how to use it in order to teach their peers.

All in all, students who take this class recommend it to other students. The class is about so much more than learning how to be a good leader. It helps students discover what kind of leader they hope to be and what it takes to get there. The information is fundamental for every college student, not only engineering majors. Theory of organization is a legacy course that will continue to explore new directions.

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## LIOTA

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η	Υ	·	..
ζ	□	·	..
ν	Δ	·	..
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σ	▷	·	..
ι	≡	·	..
α	↙	·	..
π	∟	·	..
γ	↖	·	..
λ	∠	·	..
ς	∞	·	..
ο	∩	·	..
κ	∪	·	..
λ	↗	·	..

## Lesson 1

Aa	Tt	1	15
Bb	Uu	2	16
Cc	Vv	3	17
Dd	Ww	4	18
Ee	Xx	5	19
Ff	Yy	6	20
Gg	Zz	7	
Hh		8	
Ii		9	
Jj		10	
Kk		11	
Ll		12	
Mm		13	
Nn		14	
Oo			
Pp			
Qq			
Rr			
Ss			

# Aliens in Liota Space, Part III

Vidya Vishwanathan, a Sophomore in Aerospace Engineering

I couldn't believe my ears as Vadaka delivered the good news: "Javaan has allowed you to stay!" she said. I looked from one alien to the next in disbelief. I radioed my team to tell them the good news. As expected, they replied with an ear-splitting cheer. By now, the team was very exhausted considering the hostile welcome we had received when we first arrived on this new planet.

I finally turned my attention back to Vadaka. "Thank you for your kindness," I responded. I looked at Vadaka, the communicator; Cetana, the innovator; and finally, very timidly directed my eyes to Javaan, the warrior. "My people are very tired. We require sleep and nourishment," I said. "It's been a very long day. We will commence our research once we assemble our equipment on your planet."

Vadaka almost twice my height, but was also very slender. She placed one of her several long purple-blue hands on my spacesuit. She did not talk like humans do. She com-

municated by verbally retrieving the messages and then communicating them telepathically. It was a very bizarre experience.

First I felt a rush of emotion, followed by a warm compressing sensation on my temples. It wasn't always warm though. It was scalding when Vadaka first delivered Javaan's threatening message, and icy when she was fearful. Vadaka looked up to the sky before she spoke again. "I do not understand," she began. "Our day is far from over. The Liota star is still high above." She pointed to the large red sphere of fire and gas. "But we can provide you all with sustenance," she continued. "The cuisine on Egrevnoc is highly regarded by the Liota people."

"We greatly appreciate your hospitality," I responded. Especially after you nearly murdered us all when we first arrived, I thought. "However, I cannot be sure it is safe for humans to consume food from another planet quite yet.

According to our calculations of your planet's rotation, one day on Rergoc – I mean Egrevnoc – is approximately 4.18 Earth days," I explained. "We have been awake for a prolonged period and require a short rest."

"As you wish," Vadaka replied. "You are a noble leader for foreseeing potential danger upon your people."

"Well, thank you," I replied. "However, I am not the leader of this mission."

I could see the look of surprise in Vadaka's eyes as I continued to explain to her.

"My captain is inside," I continued. "You may have seen him on the screen during our virtual tour. I am merely the correspondent for the human species."

The announcement of my occupation seemed to spark Vadaka's interest. "We shall speak soon," I said to her. I proceeded to open the airlock seal and escorted the three aliens from the spacecraft. My heart pounded as I waited for Captain Enald to let me into the oxygenic atmosphere. As soon as I removed my clunky spacesuit, a swarm of astronauts crowded around me and hugged me excitedly.

I could hardly make out one comment from the other.

"I can't believe we made it here!"

"Did you see those aliens?!"

"I thought I was going to bid my life a painful farewell."

As my fellow astronauts continued to speak, reality began to sink in. They let us stay, I thought to myself. Each word brought me to a new level of excitement, yet I still could not rid myself of the fear.

As I continued to think amongst the chorus of celebration, Captain Enald began to address the group. "We have all done an amazing job," he began. "A combination of fate and ceaseless hard work has allowed humans to travel 350 years to arrive at this destination."

He paused briefly, before he continued. "But our journey is not over yet. In fact, this is simply the beginning of a new era in human existence in deep space. We must rest now. We have a busy day ahead of us and we must be prepared for any other ..." he let out a chuckle, "surprises."

There was laughter from the astronauts before Captain Enald continued, "Congratulations Starship Terra. We have made it to Liota!"

Thundering applause consumed the room and drowned out his last words. Soon after, we all dispersed to our quarters for a well-deserved rest.

\*\*\*

"You all live on different planets?" I asked incredulously upon receiving this new information.

"Why yes," Vadaka explained. "The planets have aligned in such a way that the inhabitants of the Liota system can converge on Egrevnoc. But when our star falls below the horizon, we will leave at once to return to our home planets."

Vadaka continued, "You see, the residents of each planet each have different duties. For instance, I am from the planet Lirementem. My people are the translators of knowledge and interaction among the other planets." She began to explain the other planets to me. "There is also Kreigerin, the land of warriors; Giatros, land of the healers; Aviskaraka, land of the innovators; Gastro, land of the connoisseurs of cuisine; and many more planets to speak of."

Enald pondered on how to conduct our research. At first we had been overwhelmed by a planet of such massive proportion, but now an entire solar system?

Enald began to speak, "We are all scientists eager to learn and explore, and we all have our specialties," he said. "We will split into groups respective to each planet's occupation. We will use our shuttles to travel from Egrevnoc to the other planets and then rendezvous back here," he continued. "This shall be the initial approach. Once we congregate with our findings, we will be able to better develop a strategy for exploring each planet."

The captain then began to assign the astronauts to their planets. "Our vegetation and culinary scientists will go to Gastro," he announced as he turned to their team leader. "Aside from your established scientific goals, you must determine if the food in this system is safe for human consumption and if there is a way for this environment to support the growth of vegetation from Earth."

Captain Enald continued to divide us into groups that would follow the aliens to their planets. As the correspondent, I was assigned to follow Vadaka to her home planet.

We determined that we would all reconvene on Egrevnoc before the end of 26 Earth days. When the Liota star set and gave way to the night, the once bustling street became eerily silent as all the aliens withdrew into their space vehicles. Each alien ship rose above Egrevnoc soil, followed by one of our own.

As my shuttle lifted from Egrevnoc I realized that, just as the inhabitants of Earth had commenced on a new expedition, so had the inhabitants of the Liota system. Adventure and exploration into a new world lay ahead of us.

To be continued...



# Even in Engineering, it's all About the Money

By Miles Harnad, a freshman in general engineering

The Hybrid Electric Vehicle Team requires a lot of money, which explains all of the sponsors on their vehicle.

Photo: C.A.M. Gerlach/Engineers Forum

What comes to mind when someone mentions Virginia Tech's Ware Lab? For many people, innovation, technology and accomplishment are what come to mind. Without marketing and fundraising, senior design teams in the Ware Lab would not be able to compete. These components are equally as important to the team as the design and production aspects of development. After all, the finances needed for each team to operate has to come from somewhere!

With the help of Ware Lab Director Dewey Spangler, marketing professor Marvin Risen offers a unique approach to the economic side of the senior design teams in the Ware Lab. He does so with an innovative and hands-on class called marketing 4404. It is a small class of nine to ten students who are each assigned to work with a different design team in the Ware Lab as an associate of marketing and funds for the semester. Teams are given assistance in handling the monetary side of the competition, while marketing students receive a rare opportunity to gain first-hand experience working in a high-tech environment. This arrangement benefits the design teams as well as the marketing students.

The class gives marketing students a real working opportunity to apply the concepts that they have been taught to a real client, which in this case is an engineering senior design team. The business side of engineering cannot be

understated because, in the professional world, products are made to make money. If there is no money, there is no product. Most engineers are more inclined towards the technical side of a project rather than the monetary side. Professor Risen's class is helping to address this issue in two ways: the first way is by assigning someone to oversee the economic phase of an engineering project; the second way is by trying to bridge the communication gap between the business and technical aspects of a project.

As professor Risen claims, the students treat each team as if they were "running a bunch of little businesses." Each student is assigned to a team at the beginning of the semester based on the person's interests and compatibility with the team. The students become full members of the design teams and meet daily with the engineers to keep the project on track and stay in-sync with development. They also reach out to a mix of local and national high-tech businesses in order to obtain sponsorship and resources for each design team.

Some of the companies that have donated to design teams in the past include Ford, General Motors, Bosch and SpaceX. These companies are willing to donate money and parts because they know the value of letting potential future employees familiarize themselves with their products and their line of work.

Undergraduate  
AAST: Automotive  
AACE: Steel Bridge  
AACE: Composite Ca  
AAVT: Automotiv  
SAJA SAE (SR)  
SDC: Steel Drive C  
BOLT: Battery Dr  
DEPT: Design, Build  
Design Space of th  
Formula SAE (SR)  
Fuel Cell Project (S  
HPA: Human Power  
HPS: Human Power  
HEVT: Hybrid Electr  
IEEE: Renewable: SE  
Solar Decathlon: A



Photo: Sofia Davila/Engineers Forum

Another area in which the marketing students are helpful to design teams is in the competitions themselves. Many design competitions require a formal business presentation. Since marketing students tend to be adept at presentations, they help give teams an extra edge in their competitions by delivering sound, professional presentations.

The marketing students are also responsible for contacting past donors, and alumni, in order to establish connections that will hopefully result in more funds for the teams. For example, after discovering an existing connection with the CEO of Sunoco, one team was able to successfully obtain an annual donation from the company.

Additionally, outreach events are held for sponsors and the general public in order to show what the money that they donated is going towards, and to give the teams public recognition for their accomplishments. It is no easy task to make these connections, and the design teams are grateful for the help that they receive from the marketing students.

Marketing for the Ware Lab is not without its obstacles. One of the biggest obstacles

that the students must overcome is communication. It can be hard for business students to comprehend the technical information they receive from the design teams and vice-versa. Despite this initial barrier, the arrangement is a great opportunity for engineering and marketing students to collaborate and come to understand one another.

The Ware Lab is a place of hard work and progress, and that is how the teams overcome these differences. The experience of meeting regularly as a team and developing a team spirit can lead to strong business connections in the

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Somebody has to pay for all of these tools!

Photo: Sofia Davila/Engineers Forum

future. Taking this into account, it seems as though everyone benefits from this arrangement.

Professor Risen's marketing class will only be in its third year this spring. While Professor Risen does not anticipate the class size growing, there are still opportunities for alteration. Since each student is assigned an individual team, the course instruction and direction is individualized on a case-by-case basis. The marketing students are required to give a weekly report summarizing the previous week, looking ahead to the next week and detailing progress on team goals. This weekly influx of new information provides an opportunity for Professor Risen to improve his class' learning experience each week. This helps make the course one of the most flexible and immersive opportunities on campus. It is easy to see why some students take the

class a second semester for no credit.

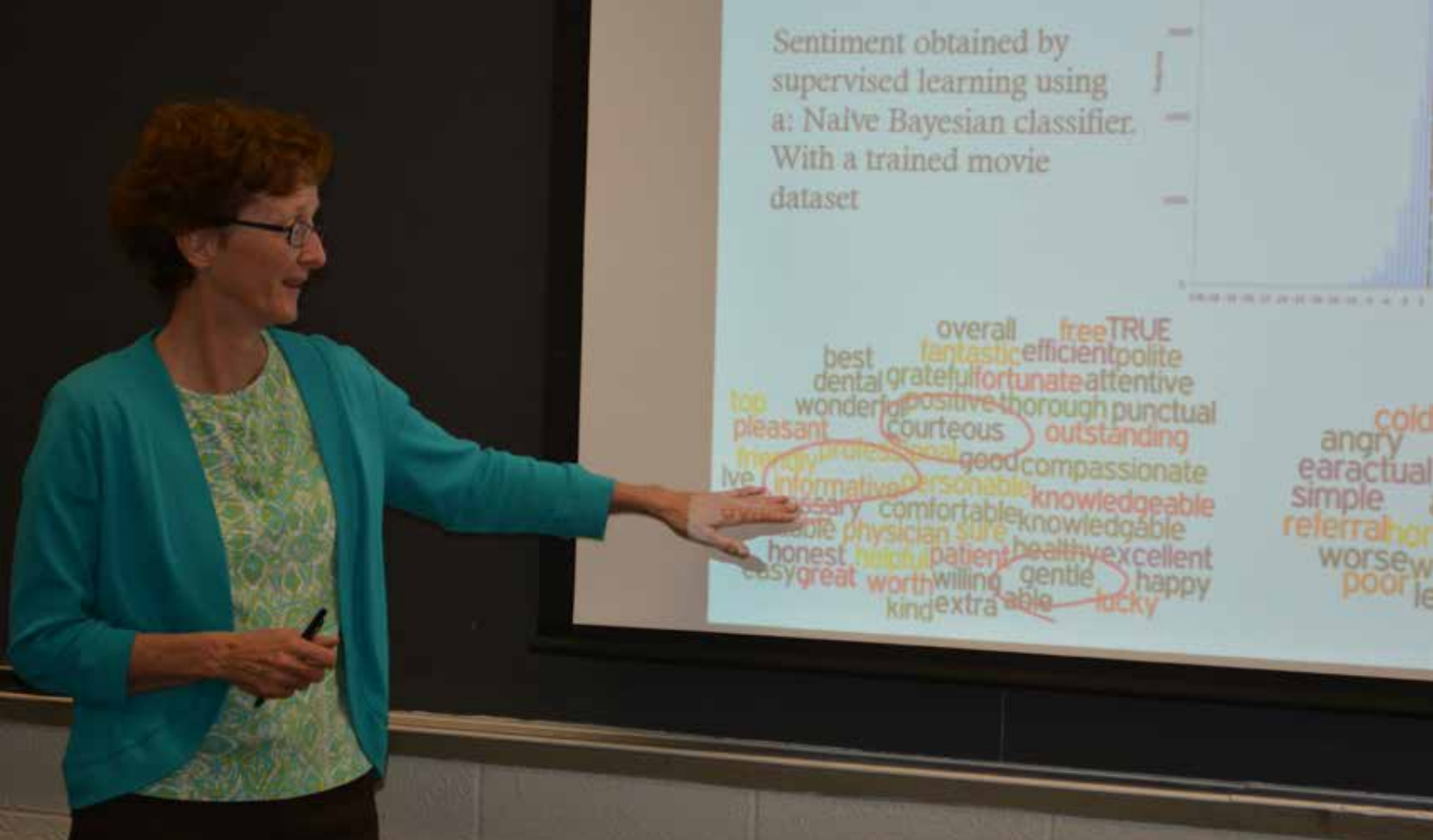
Marketing 4404 has attracted enough attention through word of mouth that it has become very competitive to get into. The benefits of getting directly involved in the technical industry are invaluable. It is not always easy to make connections in the technical industry from business school, but the Ware lab and the Marketing Department now provide an opportunity for a job in a field that many students could only dream of having. The senior design teams also benefit by having someone on the team who concentrates on the business aspects and allows them to focus their attention on designing and building their project.

By bringing business and engineering students together, Professor Risen and Dewey Spangler have created an experience like no other.



The Formula SAE team proudly recognizes their supporters on their car.

Photo: C.A.M. Gerlach/Engineers Forum



Dr. Cook points to words that can be mapped to the dimensions of assurance and empathy


## Text Mining for Service Quality

Robel Fasil, a Senior in Industrial and Systems Engineering

Text mining is the process of using analytical software to quickly extract information from a large amount of text. Eduardo Calderon, along with Dr. Deborah Cook and Dr. Tabitha James, both of the Business Information Technology Department at Virginia Tech, are working with Dr. Kellie Keeling of the University of Denver in order to research the use of text mining to assess consumer perception of the

service quality of healthcare in the United States.

Their data consists of over 700 thousand patient reviews from [www.ratemds.com](http://www.ratemds.com) that have been “text mined” in order to record the occurrence of unique words that are categorized by different aspects or dimensions of customer service such as reliability and empathy. For each review, all dimensions are given a positive or negative score. This score is determined by the leading connotations of the words that are present in the text. The scores from all of the reviews are compiled to display an estimate of the collective attitude towards aspects of service quality. This compilation offers healthcare employees additional feedback to aid in improving the customer’s overall healthcare experience.



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Processes such as text mining show how professionals specializing in several different disciplines work together in order to engineer a better world. This is evident in the way that text mining has been used to improve the quality of service in the healthcare industry.



# Replacing the Human Driver

By Kristine Mapili, a Junior in Civil Engineering

This vehicle, previously worked on for the Blind Driver Challenge by RoMeLa, the Robotics and Mechanisms Laboratory at UCLA, is now part of a project headed by Dr. Leonessa and Dr. Furukawa. The work on this functional prototype serves as an important step toward rolling out a roadworthy self-driving car.

Photo: C.A.M. Gerlach/Engineers Forum

Imagine driving on the highway, glancing over at the vehicle next to you and seeing the vehicle's driver doing something other than watching the road and the steering wheel. Instead, they are checking their email on their smartphone or tending to their baby in the backseat. How would you react to seeing this?

Although a sight like this is very rare, we could be seeing more behavior like this on the roads in a few short years. Technology in vehicles has been improving rapidly over the past few years. Nowadays it is not uncommon to see rear-view cameras and lane-keeping features included in newer vehicles. Dr. Alexander Leonessa of Virginia Tech's Mechanical Engineering Department has been working with various students at Virginia Tech on an innovation that may be taking over the roads soon: autonomous vehicles. Autonomous vehicles use sensors to detect lines on the road, as well as stop signs and other obstacles in the surrounding area. Computers are connected to actuators in the vehicle. These computers are responsible for perform-

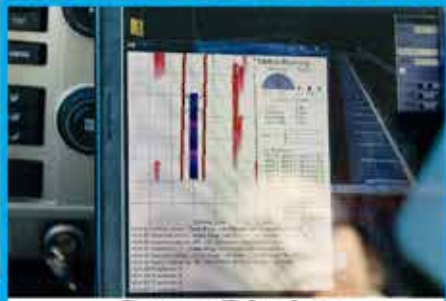
ing physical actions that a driver would normally perform such as pushing the break or the accelerator.

Autonomous vehicles are not to be confused with driverless vehicles, which are driven by the blind and are not controlled by a computer. Like autonomous vehicles, driverless vehicles gather information about the vehicle's surroundings, and are able to sense road signs, obstacles and other elements of driving.

The difference between the two types of vehicles lies in how action is taken in regards to the vehicle's surrounding. Driverless vehicles decide what action should be taken by the driver but do not complete the action themselves. For example, vibrations are used as a way for people driving driverless vehicles to know what course to take. The driver wears vibrating gloves, and the vibration felt in certain fingers to indicate to the driver which direction to turn and how much to turn. Additionally, vibrations felt in the back or bottom through seat cushions would tell the driver whether to accelerate or brake.



# Anatomy of an Autonomous Vehicle



## Status Display

Shows the world as seen through the vehicle's lidar sensors, with obstacles shown in red and the car's path in blue, along with other data.



## Remote Control

Activates the autonomous mode, monitors the vehicle from afar, and can stop it in case of trouble.



## Front Lidar Sensors

Emit pulses of laser energy, 25-50 times per second in a wide 110° arc, to help detect obstacles in the car's path. Two sensors allow a wider field of view to be scanned.



## GPS Antenna

Allows the reception of highly accurate position data to aid the vehicle's navigation system.



## Warning Light

Flashes as a safety measure whenever the vehicle is driving autonomously.



## Stop Button

Allows the vehicle to be quickly halted from the outside.



## Main Computers

One unit integrates data from the vehicle's sensors, and the other calculates the car's desired path.



## Rear Lidar Unit

Like the front lidars, but scans for obstructions behind the car.

Image: C.A.M. Gerlach/Engineers Forum

Before fully-autonomous vehicles are ready for the road, the road's infrastructure have to be adapted in order to optimize them for use by autonomous vehicles. Lines on the road can vary, and outside sensors would have to be installed in order to deal with this.

Moreover, there is the obstacle of public acceptance. It is also possible that people may be skeptical about the idea of a computer driving a vehicle. As a result, they may not trust the vehicle to transport passengers to their destination in a safe and timely manner.

Despite the potential skepticism, there are many advantages to using autonomous vehicles. One advantage is that they could be used for delivering mail and packages. The user could program a pre-defined route for the vehicle to travel, push a button and send the vehicle on its way. Also, given that efforts are being made towards efficiency and environmental sustainability in these vehicles, a road with autonomous vehicles would allow for decreased travel

times and less traffic pollution.

The best kind of environment for autonomous vehicles to operate on would be a long path of straight road, such as a highway with a steady speed limit. With the vehicle set to autonomous mode, the driver would be able to read a book or drink a cup of coffee during their commute.

Autonomous vehicles would probably not perform so well in environments like Drillfield Drive on Virginia Tech's campus during a class change. This is due to the fact that the road is filled with buses, cars, pedestrians and bicyclists all moving in different directions at different speeds. The current technology and level of programming is currently unable to process this information in order to allow the vehicle to act accordingly, and in an efficient and successful manner.

Perhaps, several years down the line, engineers will discover solutions to these obstacles allowing for more autonomous vehicles and fewer human drivers on the road.



Adam Shoemaker, a member of the Autonomous Car Team, gestures toward the autonomous vehicle's main computers. They are the heart of any successful autonomous vehicle, and must allow the car to understand its environment by integrating data from all its sensors and plan the vehicle's path accordingly.

Photo: C.A.M. Gerlach/Engineers Forum



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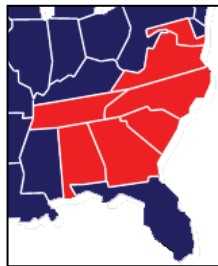
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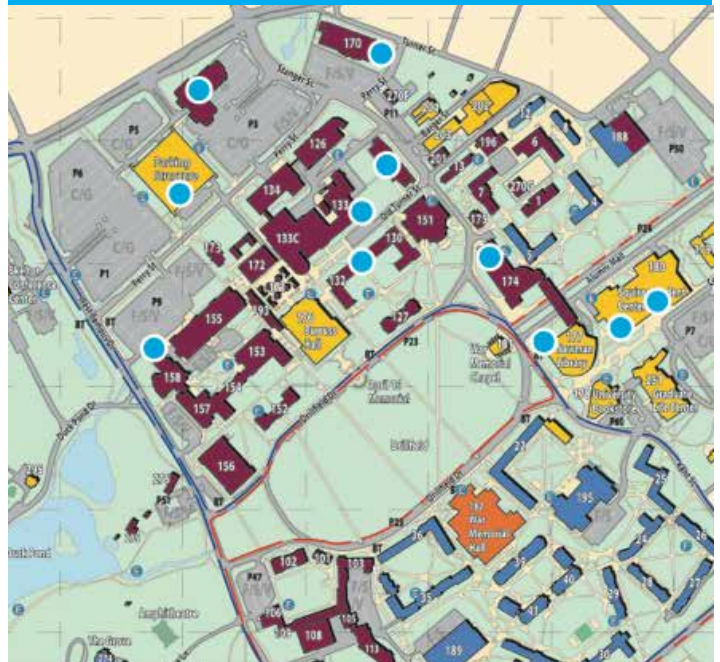
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