

READING, WRITING, AND MACHINE LEARNING

WITH HELP FROM THE SBIR PROGRAM, MACHINE LEARNING ALGORITHMS AID
IN WARFIGHTER COMMUNICATIONS

Teaching effective communication skills is a very important part of any educational system. Consider, for example, a middle school teacher evaluating and critiquing essay assignments for over 100 students in the course of a day, a task that could extend long into the evening, when weariness could adversely shape the evaluations. If there were a way for a computer to effectively review and correct these many diverse works of written communication, the results would be more consistent, and save a great deal of time and effort. Now consider military communications, where effective and consistent communications, both written and verbal, can be essential to both mission success and the safety of the Warfighters. Teaching more effective communications across a much larger and more diverse group of personnel then becomes an important military capability.

The Knowledge Analysis Technologies (KAT) engine, a precursor to modern Artificial Intelligence (AI) technology, is a computer engine capable of analyzing and providing instantaneous feedback to students about their writing. The technology uses machine learning algorithms to evaluate student writing based on ideas (concepts and how they are expressed), organization (logic and order in the writing), conventions (proper grammar, spelling, and punctuation), sentence structure and flow, word choice, and the voice, or personality, behind the writing.

The key to the KAT engine is a feature called Latent Semantic Analysis (LSA). The computer compares relevant terms within student writing to its understanding of the human language based on analysis of previously

written passages. To develop this technology, computers “read” millions of words from sources such as textbooks, Wikipedia articles, etc. Through machine learning, the computer identifies patterns and infers connections. The KAT technology can identify words that are semantically related—words such as attorneys and lawyers, or doctors and physicians—and look at how words are used in context. Dr. Peter Foltz, who helped develop the technology, explained: “For example, the word ‘physician’ and the word ‘doctor’ seldom occur together in sentences. However, they are used in similar contexts.

The computer can then infer the relationship between ‘doctor’ and ‘physician’ by looking at the words around them.” One of the goals in the development of such a technology is the ability for a computer to analyze a lot of text quickly, and understand it as a human would.

But can we trust a computer to evaluate the nuances of human-writing? To verify its efficacy, the technology was tested against the work of qualified teachers who graded the same essays.

Third party teachers agreed with the assessment of the technology as often as they agreed with each other.

The groundbreaking technology behind the KAT engine originated with Dr. Tom Landauer, a Ph.D. in Social Relations from Harvard. From a professional start at Bell Laboratories in the late sixties, Dr. Landauer’s main research revolved around human/computer interactions. Landauer passed away in 2014, and according to his obituary, “Tom believed cognitive theories should be turned into inventions that improved human learning.” One of Landauer’s colleagues at Bell, Peter Foltz, went on to work with him throughout much of



Landauer's career.

As the KAT technology began to solidify in the mid-nineties, various opportunities for applications began to emerge. In 1994, Landauer became a research professor at his undergraduate alma mater, University of Colorado Boulder. He continued to collaborate with Foltz, then a professor at New Mexico State University. The evaluation ability of the KAT engine was being field-tested at the time, and both Landauer and Foltz had, by this point, military research contracts related to the technology, the results of which were encouraging.

In 1998 Landauer, one of his graduate students, and Foltz founded the company Knowledge Analysis Technologies, "in order to be able to better commercialize some of those successes through SBIR," Foltz said, referring to the Small Business Innovation Research program. It was at this point they began to receive SBIR funding from the Department of Defense (DoD) to continue to advance the technology toward both military and commercial goals.

Dr. Joseph Psotka, retired Research Psychologist for the U.S. Army Research Institute for the Behavioral and Social Sciences, and a colleague of Landauer's, explained that the military was looking for ways to analyze soldier communication (such as radio communication between convoys, text messages and audio and video feeds) during training exercises. Their goals were to assess communication and fine-tune soldier interaction and response. Analyzing these communications allowed the military to identify and address team issues. The military also wanted to use the technology to improve soldier writing in the interest of clear communication.

Foltz said, "Much of the work we were doing for the military was in training and educational assessment. Some of the first work we did was to develop ways of scoring open-ended responses from Warfighters in scenarios." Examples that Foltz went on to give included ways of assessing non-commissioned officers



writing memos and giving them feedback on how to improve their communication, systems wherein officers were given an open-ended situation (for example, a conflict between people in the platoon) and then asked to write how they would respond. The system would evaluate the response and then give suggestions about other potential ways of responding. They also had systems that would monitor groups of officers in collaborative chat rooms solving strategic scenarios. The system would analyze the language and detect if the team was responding appropriately or getting into the weeds. If they did have problems, it would automatically give them some new topics to focus on.

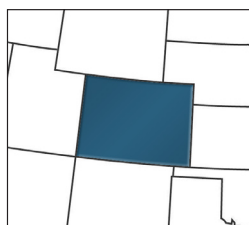
"The SBIR program supported development and commercialization of AI technology, which allowed our company to move quickly from research prototypes to products that had great impact in the training and educational markets," Foltz said. "The products are now widely used across the world and help students learn faster and help teachers be more effective."

The multinational corporation Pearson purchased Knowledge Analysis Technologies in 2004. Since 2006, Pearson has offered WritetoLearn—a web-based tool to develop reading comprehension and writing skills for students in grades 4-12.

Today, tens of millions of essays written by students each year are scored using this technology. Peter Foltz is now Vice President of AI Products and Solutions at Pearson. "We would not be here without the SBIR program," he said. "The successes in the educational application were the result of the development of the applications in the SBIRs."

The technology is also being used to assess essays in high stakes testing such as the GED, ACT-Aspire test and state assessments, corporate testing, certification for professional and government positions, and a range of English Language Learning (ELL) testing and support.

And all largely thanks to DoD's SBIR program. 🌸



Knowledge Analysis Technologies

Boulder, CO

Modernization Priority: Artificial Intelligence

SBIR contract: F41624-99-C-5003 • Agency: Air Force • Topic: Topic: AF98-010, Intelligent data mining agent for rapid and optimal deployment of war-fighting knowledge