Artificial Intelligence at NRC Health

The use of Artificial Intelligence (AI), machine learning, neural networks, and deep learning algorithms is gaining in popularity, especially in the era of Big Data. Yet these buzzwords can be a source of confusion for many. For example, AI is often thought of as an advancement in machine learning and is sometimes believed to be synonymous with neural networks and deep learning, which could not be further from the truth.

The field of AI has been around since the 1950s, and the term typically refers to a broad range of computer applications that mimic human cognition. Put simply, an AI is any computer program that attempts to behave like a person. AI programs range from simple apps that can play checkers to complex neural networks that can detect human emotions in a digital image. Due to the rising volume and complexity of data collection in healthcare, many organizations in our field are starting to turn to AI algorithms to help them discover meaningful, actionable patterns in their data.
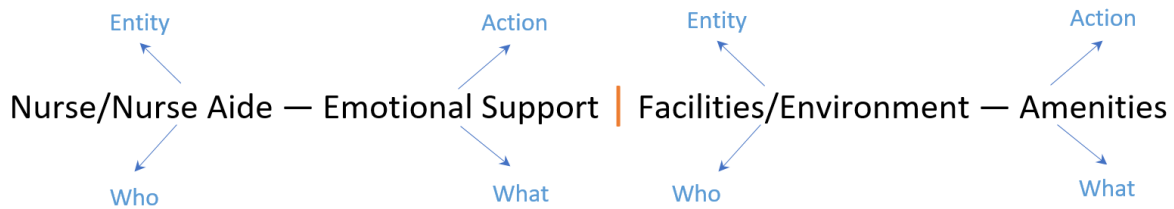
> *Collecting more than five million patient comments a year, NRC Health is a great example. We use an integrated network of AI algorithms known collectively as Natural Language Processing (NLP) to encode patient feedback and get it into the hands of frontline staff as quickly as 15 minutes after the patient shares his/her feedback. More specifically, NRC Health uses its complex AI applications for speech-to-text comment transcription, comment translation, assigning categories to comments with our healthcare-focused categorization schema, assigning sentiment to comment categories, and finally, adjusting respondent sentiment based on non-semantic factors tied to the comments left by patients.*

NRC HEALTH, AI, AND NLP

Our Real-time product uses a suite of AI algorithms to offer an automated text-analytics solution that accurately tags every comment it encounters with a healthcare-specific category. (These categories are based on a schema that was developed in partnership with the healthcare organizations NRC Health serves.) Once categories are coded, another AI application performs sentiment analysis and attaches positive, negative, or neutral sentiment to the categorized comments, at the level of each category detected within a comment. From there, category sentiment is adjusted via a machine-learning AI. Prior to processing categories and assigning sentiment, AI algorithms are also used for comment transcription and translation where needed. Accuracy across all facets of NLP exceeds 88%.

CATEGORY ANALYSIS

We asked our customers to tell us what makes a category actionable. The feedback we received was that comment categories are most actionable when they can help easily identify who a comment is about and what behavior needs to be either supported or corrected. Based on that feedback, we created a series of AI applications to tag comments with both an Entity ("Who is accountable?") and an Action ("What did that entity do?").

Entity → Nurse/Nurse Aide — Emotional Support | Facilities/Environment — Amenities ← Action

Who | What | Who | What

Comments often include references to several entities and/or parts of the care experience, and different entities can have the same or different actions assigned to them. For example, a patient might mention that she loves receiving care at a certain hospital because, "Not only does it have nice amenities, but also the nurses are very kind and caring." In this case, actions described as "very kind and caring" are clearly aligned with an entity that identifies a person's role (nurses, in this case), while "has nice amenities" is an obvious reference to the facility.

SENTIMENT ANALYSIS

Once entities and actions are assigned to each relevant part of a given comment, the next AI algorithm in the network assigns sentiment to each entity-action pairing within that comment. To do this, we deploy an industry-leading sentiment AI with dictionaries containing over ten thousand adjective phrases, adverb phrases, and emotion-bearing keywords. Then, using deep-learning engines, our AI applications parse every sentence in every comment and determine what entity-action pairs within the comment are positive, negative, or neutral. (We've "tuned" the sentiment phrase library so that medical terms and healthcare-specific situations are better understood in context.)

NRC Health is unique in the industry because most NLP solutions on the market offer sentiment at the overall level of the comment. The limitation here becomes obvious when you encounter a comment that says something like, "I loved my nurses, but my doctor was terrible." Most NLP solutions on the market will identify "loved" as positive and "terrible" as negative, but then score the sentiment as neutral—assuming, in effect, that those emotions cancel each other out. At NRC Health we analyze sentiment at the category level, so we would tag this as a positive comment about the nurses and a negative comment about the doctor, making our solution's specificity second-to-none in the market.

MACHINE LEARNING

Additionally, NRC uses a supervised machine learning AI that adjusts sentiment based on non-semantic features tied to the comment. This AI was trained on hundreds of thousands of examples and

mathematically adjusts the originally encoded sentiment for each category assigned to a comment by using the overall sentiment score, the patient's response to a key metric question, the length of the comment, and the respondent's age. (These last three factors are items that our research has shown strongly influence the likelihood that a comment is positive or negative, and testing has shown that sentiment assignment is more accurate with the model adjustment than it would be if our NLP solution was considering the comment text alone.) Teaching machines to understand human sentiment is a difficult task, but our sentiment AI is more than 88% accurate. Moreover, as time passes and more comment data gets collected, we can optimize the model and train it to become even more reliable.

ALERTS

With our NLP + AI platform, we can identify and highlight patients who may benefit from service-recovery or clinical follow-up. As with the categorization of comments, a series of complex AI algorithms comb through each comment we collect, looking for text that describes deeply negative experiences such as clinical errors, mistreatment, or privacy concerns. Additionally, NLP searches for terminology commonly used to characterize warning signs or symptoms that may need to be addressed.

TRANSCRIPTION AND TRANSLATION

Using NLP + AI for comment transcription and translation allows NRC Health to expedite the timeliness of comment and alert delivery. NLP systems are used to transcribe audio recordings while deferring more challenging transcription to human transcribers. Machine learning is also used to translate comments to English, again deferring more challenging comment transcription to human transcribers. This state-of-the-art technology allows most comments to pass through our AI platform and to the hands of front-end users in a matter of minutes.

CONTINUED LEARNING

Artificial intelligence is a moving target, and lifelong learning is key to ensuring that our AI platform remains on the cutting edge, especially because healthcare patient experiences are ever-changing. To that end, NRC Health's NLP solution is dynamic and will continue to evolve over time. Key milestones include:

January 2020:	Deployment of new Entity-Action configuration, which identifies topic areas in ways that are both important and actionable
January 2020:	Release of a non-semantic model, which adjusts sentiment based on patient age, comment length, and score on key metric
April 2020:	Release of the COVID-19 comment highlight in Analyst Corner
January 2021:	Expansion of safety/security as an action to be associated with Providers, Nurses, Care Team, and Admin/Reception
January 2021:	Refinement of the algorithm for Clinical Error alerts

NRC Health continuously reviews feedback from clients and makes changes to the NLP solution. Upcoming and ongoing updates include:

→ Reviewing client-opened/removed alerts to examine how accuracy can be improved

→ Reviewing client revisions to categorization and sentiment to examine how accuracy can be improved

→ Comparison of hand-coded comments to current configuration, resulting in the full-scale revision of queries

→ Updates to the Qualitative and Feedback Management display within the Real-time portal for a better user experience

NRC Health also continuously reviews industry trends in the usage of Artificial Intelligence to illuminate additional areas of innovation.