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"Digital Decision-Making: The Building Blocks of Machine Learning and Artificial Intelligence"
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Chairman Wicker, Ranking Member Schatz, and Members of the Committee, thank you for the opportunity to appear before you today. I am Dr. Cindy Bethel, an Associate Professor of Computer Science and Engineering, the Billie J. Ball Endowed Professor in Engineering, and the Director of the Social, Therapeutic, and Robotic Systems (STaRS) Lab at Mississippi State University. It is an honor to speak with the committee today about digital decision-making associated with artificial intelligence (AI) from the academic perspective and about applications of AI being developed at Mississippi State University.

A critical aspect associated with the advancement of science and technology is the development of algorithms associated with AI including machine learning for digital decision-making. In order for a system to make a decision it must acquire information, have a means of processing and learning from that information, and have the ability to use that information to make an informed decision. The gold standard would be the ability for a machine or system to make a decision in a manner similar to that of a human who is an expert in that area. We have made considerable progress toward this goal since the inception of what is considered artificial intelligence, which began in 1943 with the research performed by McCulloch and Pitts. Today many machines and systems rely upon the use of artificial intelligence for digital decision-making. This is a relatively new field of science that will provide many lifetimes of research including efforts to enhance existing algorithms and develop new, more efficient, and effective algorithms. This is critical to the overall advancements of science in many disciplines, such as robotics, medicine, economics, and many others. There are often disagreements in the field as to what is considered AI and what algorithms and techniques used for learning are considered the best.

There are many application areas for which artificial intelligence is beneficial and may make a significant impact on society. At Mississippi State University, we are actively conducting AI research with several research projects that use AI and machine learning techniques, but I will focus on three primary projects.

The first project is the integration of robots into law enforcement operations, especially high risk, life critical incident responses such as those used with special weapons and tactics (SWAT) teams. I have been training monthly with rural regional SWAT team members since 2011. This is an example of an application in which high risk, dynamic situations are encountered, that require often officers to make life-critical decisions. The more information or intelligence they have prior to entering these dangerous and unknown environments, the better decisions the officers can make. We are investigating and developing algorithms related to computer vision, sensor fusion, and scene understanding to send a robot

in prior to entry to provide audio and video feedback to officers during a response, highlighting what is critical information for them to attend to so that they are not overwhelmed with information when under high stress. The algorithms identify what is important to the officers in the environment, such as children, weapons, and other possible threats. This information can change the dynamics of how they make entry or process the scene. We are also researching in what ways this information needs to be provided to the officers, so that they can use it to their advantage to keep them and others safer in the performance of their duties. For example if officers are conducting a slow and methodical search of a building for a suspect, and the environment is quiet, dark and threat is nearby, they would not want to receive the information in a openly visual manner such as a video stream on a mobile phone that would highlight them in the environment and make them more likely to be the target of harm. In this case, they may want a verbal description of the scene that comes across on their radio earpiece. If they are in a gunfight or if there is an alarm that is sounding in the environment, but they are in a relatively "safe" location, then they may want to receive this information in a visual form, because audio transmission would be difficult to hear. We are researching the development of intelligent interface switching in which the manner that information is delivered to the officers may change depending on what is happening in the environment they are operating in. The officers are excited and ready to start deploying some of these artificial intelligence and machine learning applications in real-world responses.

A second project that we are working on at MSU is the development of autonomous cargo transport systems to be used in the fast-paced, dynamic environment of a top 100 logistics company. A primary factor that needs to be considered is what sensors need to be used to make informed decisions on the path the vehicles must travel. We also need to consider humans, who are sitting in the driver's seat of these vehicles, because control of the vehicles will change between fully autonomous to human driver operated. Research has shown that if the human is not actively involved in the activity of driving, that there may not be adequate situation awareness to be able to take back control of the vehicle with relatively short notice if needed. This has potential for life critical decision-making. We are investigating how the system needs to be able to alert the driver that control is being transferred, either to the vehicle or back to the human driver.

It is also important to consider the types of notifications that need to occur to ensure safety and situational awareness of what is happening around the vehicle. Also there are situations in which humans are operating in close proximity to the autonomous vehicle. As human drivers, we observe consciously or unconsciously behaviors of other drivers to infer what nearby vehicles will do next, but if there are not those cues, then how do humans in the environment understand what the vehicle or system will do next? This is a major issue of concern. This occurs also when the vehicle is docking to deliver cargo and a human is involved in unloading and loading this cargo. We are exploring methods of notification to the person about what the vehicle will do next. This is of significant concern, and if the incorrect decision is made, the vehicle could cause harm to the human.

The third project involves a robotic therapy support system, known as Therabot™ that is in the form of a stuffed robotic dog. Therabot™ is an alternative to animal-assisted therapy, for people who may be allergic to animals or may not be able to care for a live animal. Therabot™ will be used to provide support during clinical therapy sessions and for home therapy practice with children or adults who are dealing with post-traumatic stress disorders and other mental health concerns. The algorithms being

developed for this project modify the autonomous behaviors and responses of the robot based on the interactions with the human to accommodate his or her preferences and in response to different levels of stress detected. Machine learning is being used to understand what behaviors the user prefers and to provide better support. It allows Therabot™ to be customizable to each individual user. It will learn and respond to each user as a dog would each person it encounters. Currently, Therabot™ can detect different types of touch, such as petting, patting, and hugging and will respond in different ways. If a person is under stress during the interaction he or she may squeeze the robot and the robot will adapt its behaviors to provide more comfort and support.

Algorithms used in the research and development of systems that are capable of digital decision-making are being developed and enhanced by researchers all across the world. Mississippi State University is at the forefront of these research developments and is continually contributing through publications and sharing of knowledge, algorithms, and software developments.

Research as a whole involves exploring what others have performed and then determining if there are modifications that can be made to improve upon those algorithms or the development of new algorithms to meet the needs of the application of use. For example, algorithms are being developed to learn a user's preference for how close a robot stands to them and still feel comfortable, or which friend they like most on a social media account. There are many methods for solving a problem. I typically tell my students who are interested in pursuing research that "you need to be first or best at something and it is always best to be first."

Artificial intelligence will only be as good as the data the system receives and its ability to process that information to make a decision. This is a critical aspect to the advancement of this field that can impact almost any other discipline. The system or machine must have the ability to perceive information and that typically comes from sensors and other forms of data. There are many types of sensing systems such as a camera, streaming video, thermal images based on the heat signature of items in the environment, radar, and many others. There are also methods of gathering information from sources such as social media, mobile device location history, purchase history, product preferences, websites visited, etc., that can assist in the decision-making process. The better the quality and quantity of information available to the system, the better the results will be from the machine learning process, which results in a better final decision from the system.

Algorithms are programmed to receive data as an input, process that data, learn from large amounts of data, and then use that information to make a digital decision. If there is not sufficient amounts of data available to train the machine learning algorithms or enough diversity in the data to allow the learning algorithms to adapt to different aspects, then the decision-making capabilities can be limited or inaccurate.

Another major issue of concern is the processing power necessary to handle large amounts of information received and come to a decision. This is especially a concern on smaller systems such as robots that have limited onboard processing capabilities. Many of the AI problems that are being addressed in the research community are performed on high powered computing resources and simulations are performed to validate the results. This is fine for many scientific applications, but in order for AI and machine learning to be beneficial in real-world applications, it will be necessary to perform the decision-making processes

in real-time. The results need to be made available in an instant and not have to wait for processing time to provide a result. This is improving, but sensing and processing are currently significant limitations to the application and use of AI in digital decision-making.

The level of human engagement necessary for digital decision-making depends on the state of the AI system. There are different levels of autonomous decision making. There is full autonomy, where the system receives the input and then processes the information from that data and makes a decision with no input from a human. There is supervised autonomy, in which the system receives information, processes the data, and comes up with possible results, and the human may have the ability to override or make the final decision. The more common level of autonomy is supervised autonomy. The level of human engagement also needs to consider the ramifications of the decision-making process. If it is a life-critical decision, then most people are more comfortable with a human remaining involved in the process to ensure an ethical and "good" decision is the final result. There are many ethical hurdles that will need to be decided at some point as to who is responsible if an AI system makes an incorrect decision, especially if the decision could result in harm to humans. There have been discussions in the field among researchers regarding who is responsible for this decision, such as the programmer, the company that made the system, or others. The current state often requires a human to be involved at some level of the final decision-making process unless it is low risk or well validated that the system will always make a "right" decision.

The fields of artificial intelligence and machine learning are at such an early stage of scientific development that standards and best practices are discussed among researchers; however, there is not a single standard or set of best practices that I am aware of that all researchers and scientists follow at this point. The biggest concern is providing the best possible answers that will not result in harm and provides benefits to the users.

The algorithms developed for machine learning and artificial intelligence can be used in almost any area of research, development, and discipline. It can be used to improve the decision-making process of humans. The processing of some information by a computer can be faster than what can be achieved by a human brain. Almost any aspect of society can benefit from the use of high quality artificial intelligence capabilities.

A critical aspect in the development of artificial intelligence using machine learning and other techniques is the impact on the humans that are involved. A current limitation to the advancement of artificial intelligence is the quality and cost effectiveness of sensing capabilities to provide high quality information or data to the system to make those digital decisions. Another critical limitation to current artificial intelligence capabilities is onboard processing capabilities and the cost effectiveness of those systems. We have come a long way in the advancement of artificial intelligence; however we still have a long way to go! The potential applications of AI are almost limitless. The United States can and should remain at the forefront of AI research, application development, and innovation provided that the government proceeds with a light regulatory touch that doesn't stifle this potential.

Thank you so much for the opportunity to testify today on these important topics. I appreciate your time and attention to the advancement and impacts of digital decision-making and artificial intelligence.