Undergraduate Thesis Prospectus

Proactive Planning and Control of Autonomous Vehicles

(technical research project in Systems Engineering)

Creativity and Legitimacy in Artificially Generated Art

(sociotechnical research project)

by

Jeremiah Thomas

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technical project collaborators:

Grace Glaubit
Katie Kleeman
Noelle Law

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.
Jeremiah Thomas

Technical advisor: Nicola Bezzo, Department of Systems Engineering

STS advisor: Peter Norton, Department of Engineering and Society

General Research Problem

How can computer programs be used to interpret unstructured data?

Computers typically execute lists of programmed instructions, but in deep machine learning, computers bypass such instructions to self-optimize and develop their own rules consistent with human-prescribed goals. Unsupervised deep learning, or deep learning in which computers learn from themselves without strictly defined goals, may now be feasible (Goodfellow et al., 2014). In situations with well-defined goals, such as vehicle control, machine learning can support systems that may perform well in certain new, unstructured scenarios. However, in situations with subjective and complex goals, unsupervised deep learning may have the potential to support a "computational creative system" that solves human problems without human input (Elgammal et al., 2017). Such developments raise questions about what it means to exhibit creativity and the relative importance of artists and tools in the expression of art.

Proactive Planning and Control of Autonomous Vehicles

How can an autonomous vehicle be programmed to plan its course in an unstructured environment?

I will create a method for autonomous vehicles to plan their speed and trajectory in advance to safely traverse unknown terrain. The project is advised by Professor Nicola Bezzo in the Systems Engineering department, and I will work with three other undergraduate engineers: Grace Glaubit, Katie Kleeman, and Noelle Law. We will perform a literature review of algorithms and machine learning models to control a ground vehicle's motion and path planning in uncertain and unstructured environments.

Then, we will use the Gazebo robotics simulator to create test environments with different levels of friction and various obstacle configurations.

Researchers have created control systems for autonomous vehicles using reinforcement learning (Josef & Degani, 2020) and terrain classification (Ono et al., 2015). However, reinforcement learning uses rewards defined by humans and terrain classification is based on expert categorization of terrains and terrain safety. We seek to implement a velocity control system that can independently learn from unstructured environmental data. We will run experiments in Gazebo and train a deep neural network using parameters such as friction, path angle, and allowed spatial deviation. The network will predict safe velocities in novel environments without additional training or human input. If possible, we will transfer our framework to physical vehicles in Professor Bezzo's Autonomous Mobile Robots Lab in the spring and add additional path planning capabilities such as risk-aware decision making to choose between multiple paths.

Creativity and Legitimacy in Artificially Generated Art

How are tech enthusiasts striving to promote the legitimacy of AI-generated art?

Recently, computational artists like Mario Klingemann have moved beyond simple, rule-based pieces (Klingemann, 2006) to artwork generated by machine learning (Fig 1).

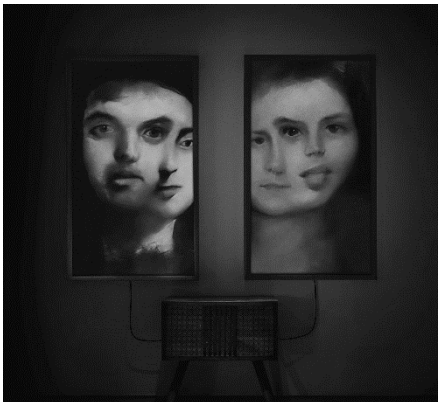

Figure 1. Memories of Passerby I by Mario Klingemann (Sotheby's, 2019)

Advances in artificial intelligence raise questions about the legitimacy of artificially generated artwork, including whether it is indeed art

at all, and where whatever creativity it expresses resides: in the computer or in its programmer. Tech enthusiasts are promoting acceptance of purely AI-generated art in critical circles, sometimes in opposition to artists who view computers as an artistic tool and not an independent creator.

Groups of artists use AI differently. Traditional painter Ronan Barrot (2019) uses artificially generated art as inspiration, Harold Cohen (Cohen, 2016) built a robotic painter but did not believe it was intelligent and modified its output by hand, and Mario Klingemann (2006) creates fully generative installations. Tech company RunwayML is developing AI as a tool for artists (MIT Docubase). Auctions at Christie's (2018) and Sotheby's (2019) reveal the success of tech enthusiast artists in convincing critics and collectors that AI is more than a tool and that it can create artwork independently from human input.

Harold Cohen spent 35 years working on a painting algorithm/robot called AARON. While AARON "has a degree of autonomy" and could be considered creative, Cohen "never made such a claim" about it because it lacked "lifelong intellectual development" (2006). Instead, AARON can be viewed as an "extended mind" or "designer environment" that encoded and amplified Cohen's knowledge about the rules of color, stroke, and shape without independent development or creativity (Sundararajan, 2014).

Generative Adversarial Networks (GANs) are neural networks that mainly learn from unstructured image data without further human input. Inside a GAN, one network generates new images and one network categorizes them as real or fake. Unlike in conventional deep learning, which evaluates inputs, the generating network learns to

make images that resemble the training images (Goodfellow et al, 2014). Researchers at Rutgers argue that their modified GAN not only learns enough to produce images that replicate training images, but also can "deviate from established styles" provided in the training data (Elgammal et al., 2017). The learning and creative behavior that they are working towards is exactly what Cohen thought AARON was not capable of doing.

Many artists are skeptical that AI can independently generate novel artwork. Mario Klingemann says what he does is similar to "work with brushes or real material" and calls the computer a tool to "help [him] create interesting images." Until recently, he did not consider himself an artist (Klingemann, 2018). Cristóbal Valenzuela, the founder of RunwayML, agrees that AI is useful for art, but he sees it "more like a collaborator" that can help people who are already creating art enhance their creativity. His goal is to "get even more people on board" as machine learning models turn into "commodities" that can be used by the average artist, not to let computers generate images at random (MIT Docubase). The group behind the Christie's auction agrees the most with the researchers from Rutgers. Like Valenzuela, they envision "new generations of creators… where the hand of the artist and the one of the machine are joined." But they also believe that their work will eventually "create a machine that is capable of being creative" (Obvious, 2020).

The researchers at Rutgers suggest that the push for artificial art as legitimate parallels the push for acceptance of photography as art during the 20th century, and that even if artificial paintings are only a reproduction of training paintings (although their 2017 paper suggests otherwise), they are still a form of representational art (Mazzone and Elgammal, 2019). Art specialist Richard Lloyd support the push. Lloyd organized the

auction at Christie's and says that artificial intelligence will be a "revolution" in the art world (Christie's, 2018).

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