Carbon Capture, Utilization, and Storage from Power Plant Emissions

(Technical Paper)

A Study of Artificial Intelligence for Creative Uses in Music

(STS Paper)

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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

Introduction

Evolution within the field of artificial intelligence over the last ten years has been remarkable, with this major growth affecting nearly all aspects of society. As artificial intelligence (AI) has grown within typical problem-solving spaces, it has also emerged in more creative spaces as well, where the potential to build truly "creative" systems has emerged as a legitimate possibility for the future. Some of this creative growth has been focused on the music industry, where many current artists use AI composition tools to assist with the song-making process ("A.I. Songwriting Has Arrived. Don't Panic," 2018). The STS portion of this proposal will involve the analysis of current and future creative artificial intelligence technologies in the field of music.

The STS and technical portions of this proposal will vary greatly, with the technical portion covering carbon capture, utilization and storage. As the world's population continues to grow exponentially, energy demands increase proportionally, and although renewable energy sources are becoming more prevalent, "fossil fuels [will] still account for more than three-quarters of world energy consumption through 2040" (Doman, 2017). Thus, while furthering development of renewable fuels positively contributes to lessening reliance on fossil fuel-driven energy sources, action must be taken to reduce carbon dioxide emissions to provide an immediate, viable solution to the world's energy crisis. The technical portion of this analysis pertains to the design of an effective application of carbon capture, utilization and storage (CCUS) technology, a method that has the potential to reverse alarming emissions trends.

Technical Topic: Carbon Capture, Utilization, and Storage

CCUS involves removing carbon dioxide from gaseous byproduct streams produced in industrial processes and storing or using it to create valuable products, including fuels. While CCUS has been applied to pilot-scale operations, industries have yet to put forth financial resources required to create large-scale systems. The primary challenge preventing this commitment is the drastic energy demand of separating carbon dioxide from other gases, resulting in a high cost. Based on initial CCUS designs, this single step alone "could consume 25 to 40% of the fuel energy of a power plant" (Haszeldine, 2009, p. 1648). In order for CCUS technology to thrive, design of the separation process must be optimized to decrease its associated cost, which is the most pressing challenge and one of the primary objectives associated with the technical project. The design must not only be economically viable, but additionally must operate as efficiently as possible while taking safety and environmental concerns into account. Based on preliminary research, removal of carbon dioxide from emissions streams at coal-fired power plants using monoethanolamine (MEA), a chemical solvent, is a viable approach for the design of CCUS technology.

Power plants that rely on fossil fuels as a source of energy burn the substance at high temperatures, producing flue-gas as a result of combustion, a vapor stream that includes carbon dioxide as well as water vapor, nitrogen, oxygen, and traces of other gases. In order to begin the CCUS process, carbon dioxide must be separated from other species, producing carbon dioxide with the highest possible purity. The overall separation process is represented by the "Separation System" block within *Figure 1*, which outlines the process of CCUS. The first step of separation involves cooling flue-gas and feeding it to an absorption column, where it comes into contact with MEA solvent, which absorbs carbon dioxide, separating it from other gaseous compounds. The resulting solvent stream, which is rich in carbon dioxide, is heated and fed to a stripping column, where additional heating causes chemical bonds to break, allowing carbon dioxide to be released and collected (Liao et al., 2018, p. 528).

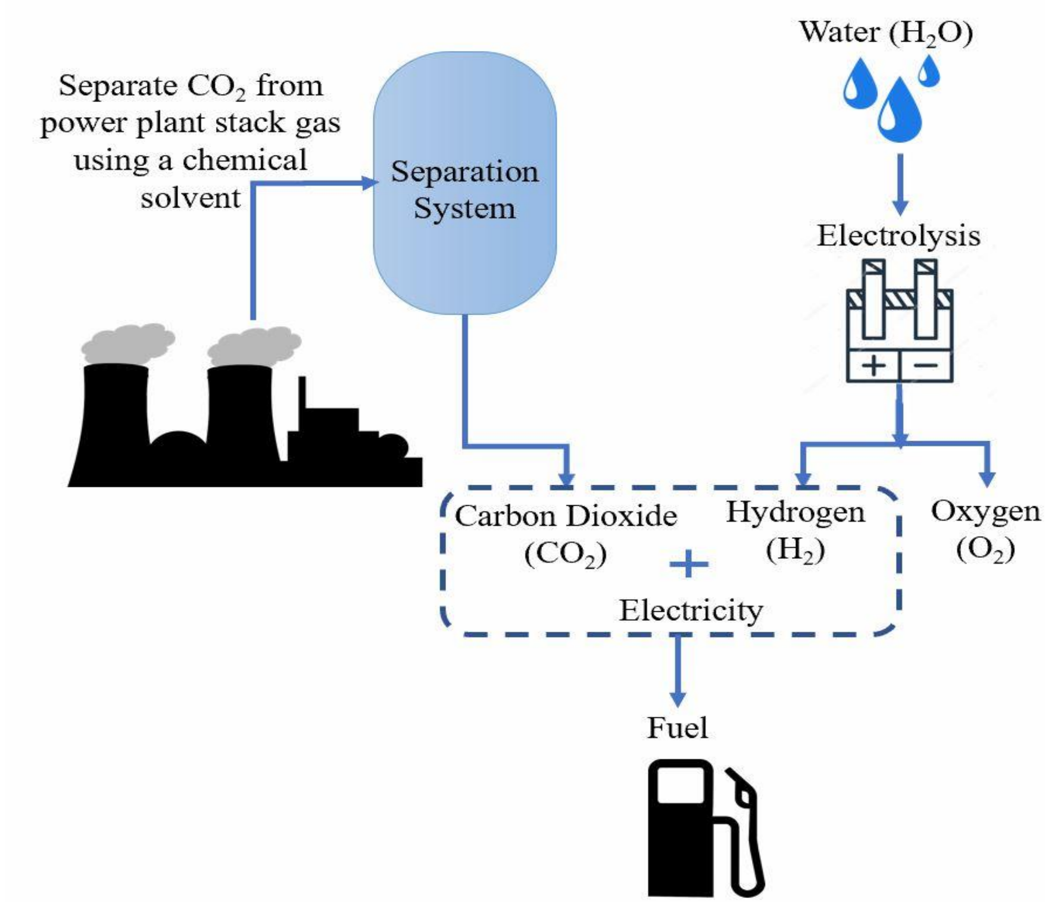

Figure 1: The pathway of carbon capture, utilization and storage: CCUS begins with the separation of CO_2 from an emissions stream such as flue-gas from a power plant, after which it can be combined with hydrogen and electricity to produce renewable fuel (Magner, 2019).

As shown in Figure 1, the CCUS process additionally includes the electrolysis of water, which involves running an electric current through water molecules to break them into their individual elements, hydrogen and oxygen. Separated carbon dioxide and hydrogen can be combined with energy in the form of electricity in order to produce fuel, which provides "a potentially cost-competitive way to make gasoline, diesel, or jet fuel that doesn't add any additional CO_2 to the atmosphere" (Leahy, 2018). The use of carbon dioxide to produce an alternative fuel source significantly increases economic feasibility of the CCUS process. Although use of MEA to separate carbon dioxide from flue-gas is criticized due to significant energy demands associated with regenerating solvent, combining this separation technique with production of fuel is a novel approach that has the potential to maximize efficiency and economic yield (Luis, P., 2016, p. 94). By developing a model of this process for a specific industrial power plant, including detailed simulation of process equipment and layout, calculation of heat and material balances to determine properties of inputs and outputs, and an analysis of economic feasibility of the design, the intended outcome is to determine optimal conditions for applying CCUS technology.

The ultimate goal of this technical project is to contribute to the creation of a more sustainable future in the energy sector, meeting the objective of the Paris Agreement, which, according to Zheng et al. (2018), "…is that the global average temperature must be controlled within 2 °C in this century" (p. 1). Through the technical analysis, which will be presented in the form of a scholarly article, the chosen approach to CCUS technology will be evaluated based on its viability in both reducing carbon dioxide emissions at their source, and transforming this compound from a pollutant into an economically feasible source of renewable fuel. Creating a successful design for CCUS encourages widespread application of this technology, which has the potential to alter the trajectory of the energy industry, preserving the future of Earth's climate.

STS Topic: Musical Creation through Artificial Intelligence

Artificial intelligence has emerged in creative spaces far more recently when compared to the longer history of AI, which began as a concept in the mid-1950s when American mathematician Norbert Wiener determined that intelligent behavior is dependent on feedback mechanisms that could be simulated by machines ("World-Information.Org," n.d.). The first example of an artificially intelligent program was the *Logic Theorist* program created by computer scientist Allen Newell and cognitive scientist Herbert Simon. This program was created for the purpose of proving mathematical theories given basic rules of logic (Gugerty, 2006), though Newell and Simon also examined the possibility of using computers to emulate creative thought alongside computer scientist J.C. Shaw. They assert that the solution to a problem can be labeled as creative if it is new and useful, clarifies a vague problem, and contradicts previous ideas or prevailing lines of thought (Newell, Shaw, & Simon, 1959). One method of determining whether artificial intelligence can mimic human traits or creations is known as a Turing test, which is an "imitation game" that generally asks human test subjects to distinguish between interactions with humans and interactions with computers ("Turing test | Definition & Facts," n.d.). An example of a musical Turing test involves asking test subjects to choose which songs in a mixed playlist are produced by humans and which are produced through artificial intelligence (Rajon, n.d.). Tests of this nature are very important steps that can be taken to assess the plausibility of creative AI.

Music is one of the most important and ubiquitous cultural elements of any society, and artists and musicians constantly work to improve their craft and reach larger audiences. The process of creating music is undeniably "human," as creativity and emotion are two of the most touted characteristics when it comes to the final output. There are several aspects of the musical creation process, but the two that will be examined involve instrumental composition and lyric writing; each of these features is vastly important to the process of song creation and can be modeled using artificial intelligence.

The AI and music industries have become increasingly interconnected as of late, with predictions that within ten years, up to 30% of all Top-40 singles will have been produced using artificial intelligence ("A.I. Songwriting Has Arrived. Don't Panic," 2018). Given recent pushes towards natural language processing, which allows computers to understand and shape human language ("What is Natural Language Processing?," n.d.), there is also the potential to mimic patterns in written words to produce new text (Yager, 2018). This computer-generated text could then be applied to an artificially-produced instrumental, giving an entire song generated by computer with no human input.

Given that the current states and directions of these two stakeholders are very quickly shifting and time-dependent, the theory of technological momentum will provide the best context towards the interactions between the two groups over time. Within this framework, technological historian Thomas Hughes asserts that technology and society strongly influence each other in a relationship that can vary over time (Hughes, n.d.), which has been evident throughout the history of AI in the music industry. There are critics, however, who would argue against any deterministic component of technology (Nye, 2007), which is a significant aspect of technological momentum. These critiques will be addressed throughout the research paper as the potential impacts on society of AI successfully creating music are examined.

Actor-network theory (ANT) will also have merit as a way to analyze the complicated relationship between artificial intelligence and the many subgroups within the musical community. The actor-network theory would allow for some of the interactions between these ancillary groups and processes to be considered in the grand scope of the relationship between the two main actors, as ANT focuses on constantly changing relationships and the networks impacted by these changes (Cressman, n.d.). The critics of actor-network theory would argue that all groups examined are treated equally in terms of influence and impacts, which could raise issues when examining smaller subgroups within each large stakeholder.

This research is very socially relevant because of cultural importance that music maintains in society. The ramifications of a computer being able to mimic and emulate the extremely abstract and emotional thoughts prevalent in music to the point where they can impact an individual consumer in the same way that another human can could potentially be a strong indicator of basic human-computer interactions in the future.

Research Question and Methods

What is the current state of artificial intelligence within the music industry, and how would the ability of AI to emulate human creativity within the music-making process impact society?

To pursue this research question, background and case study research will first be conducted on various technological developments within the artificial intelligence community involving music generation, creative computing, emotional identification, or natural language processing and text generation. A Turing test may also be employed using previous AI-generated music. Personal interviews will also be examined or conducted with various individuals involved in the communities of music, artificial intelligence, or both. Perspectives from the general population of music consumers through sales and streaming statistics will also be useful in determining potential impacts of AI in music on the broader public.

Conclusion

One of the largest issues in terms of the state of the environment in the 21st century involves greenhouse gas emissions from industrial processes. The technical deliverable of the Capstone project is a model of a carbon capture system to produce clean fuel from power plant stack gas. This model will outline the process and power plant specifications required to effectively remove CO_2 from a natural gas power plant and transform it into fuel in an economically feasible manner, thus helping solve some of the environmental issues associated with power generation.

The growth and evolution of artificial intelligence is a main technological concern in society today. This STS report will deliver an analysis of the current state of artificial intelligence within the music community followed by potential future developments and corresponding ramifications. The impact of AI on music will act as a case study for potential impacts of purely creative AI on society as a whole.

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