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The Future of Computer Music
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What if I told you to listen to a profound piece of classical music and meditate on the

potential meaning behind the work? You would likely tell me a story about the composer's

feeling of struggle or love or fear or joyousness. You would likely compare the composer's

emotions to your own human experience. What if you subsequently discovered, though, that the

composer wasn't a human at all, but a computer? Iamus, a computer cluster developed by

Francisco Vico and Gustavo Diaz-Jerez at the University of Malaga in Spain autonomously

composes full scores of contemporary classical music from scratch, and fools many listeners for

a human musician.[1] Iamus has been afforded more serious attention than any of the past

attempts to make music by a computer because it can mimic not only human intelligence but also

human creativity and intention through its Darwinian evolutionary algorithm. Unsurprisingly,

though, Iamus' ability to replicate innate human characteristics has made the computer cluster

very controversial. Thus, the idea that a computer can mimic and induce human emotion is not

yet accepted enough for the world to fully embrace all of Iamus' capabilities in the near future,

but musicians should take advantage of Iamus' ability to generate new styles and genres today.

Iamus is an AI system that uses Darwinian evolutionary processing to autonomously

compose full works of modern classical music and also generate new styles and genres within

classical music. An AI system is a "complex algorithms system powered by a computer with the

ability to learn from data and independently make decisions that mimic human intelligence."[2]

Many past artificially intelligent music composition tools have used traditional AI techniques,

[1] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[2] Penney, "Algorithms in Music: Blessing or Curse?"

but Iamus employs a new development in AI, a "bioinspired" approach based on evolutionary Darwinian natural processes and indirect encoding.[3] In biology, multicellular living organisms, like you and I, develop from a genome and evolve in time. This is the process that evolutionary computation and artificial development mimics.[4] In other words, Iamus is an algorithm that mimics the process of natural selection.[5] It starts by generating at random a very simple "musical genome," a small fragment of music which encodes the specifications to evolve into a music piece following a complex developmental process.[6] The computer then starts to mutate the genome, after each mutation passing the sound into a fitness function that assesses whether the result conforms to certain formal musical constraints and basic aesthetic principles.[7] If the mutation passes the fitness function, meaning the algorithm believes that it is fit enough to eventually become a "formally correct and potentially beautiful musical form," then the evolution of the genome continues.[8][9] Iamus continues to mutate, transform, and add to the genome, with each step it becomes more and more like real music and better fit to the requirements.[10] This "evolutionary process" stops when all the rules are met.[11][12] Furthermore, the effect of this evolutionary algorithm is a capability that makes Iamus special-- the ability to create new classical music styles and genres. Most algorithms for computer composing have focused on imitating preexisting human styles and learning by examples. This Darwinian

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[3] Penney.
[4] Quintana et al., "Melomics: A Case-Study of AI in Spain."
[5] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[6] Quintana et al., "Melomics: A Case-Study of AI in Spain."
[7] Quintana et al.
[8] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[9] Quintana et al., "Melomics: A Case-Study of AI in Spain."
[10] Quintana et al.
[11] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[12] Ball, "Algorithmic Rapture: Philip Ball Listens in on an Album of Evolved Music Composed by the Darwinian Computer Program Iamus.(COMPUTER SCIENCE)."

process, though, makes Iamus different and better by providing the system with knowledge about music composition to let it invent new styles.[13] In other words, instead of showing the computer some examples and telling it to follow certain rules, Iamus can create its own styles and write its own sets of rules.[14] Iamus' *Opus one* created on October 15, 2010 is "the first fragment of professional contemporary classical music ever composed by a computer in its own style rather than attempting to emulate the style of existing composers."[15] Thus, Iamus can invent "new fusion genres" and "new hybrid music styles," acting like "an automated form of brainstorming" for musicians who want to compose works following new completely unique musical rules.[16] All in all, Iamus' application of this new AI technology not only allows it to create full modern classical pieces of music without any human intervention, but also makes it a useful and inspirational tool for human composers.

In the past, musicians have used algorithms as a supplementary tool in their composing, but there was never a question of their authorship of the music. For decades human composers have been using algorithmic procedures as supplementary compositional tools, known as "Computer-Aided Algorithmic Composition" (CAAC) or "Computer Assisted Composition" (CAC).[17] These methods did not use the computer to make aesthetic decisions, rather, perhaps to perform mathematical manipulations of the piece or randomizations more efficiently. In such cases of computer aided composition, the musician would select and tweak the most aesthetically pleasing arrangement generated by the algorithm. So, although the algorithm helped along the way, the composer was the clear and only author of the music. For example, for Robert J.

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[13] Quintana et al., "Melomics: A Case-Study of AI in Spain."
[14] Penney, "Algorithms in Music: Blessing or Curse?"
[15] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[16] Quintana et al., "Melomics: A Case-Study of AI in Spain."
[17] Penney, "Algorithms in Music: Blessing or Curse?"

Frank's *Der Mozartgeist* (1994) devised an algorithm to generate a section of music to fit well within the rest of his manually composed music, "setting its parameters and trimming notes when desired until he hit on something that he liked."[18] Because Frank had complete control over the aesthetic product, carefully overseeing and altering the output produced by the computer, "his agency in the process and his authorship of the composition are hardly disputable."[19] In another example, performer-composer Austin Lemmons used both a random number generator and the Bubble Sort algorithm as "organizational decision-makers" for his composition *Algorithm for Trumpet* (2016).[20] Lemmons nevertheless took complete ownership, stating, "I still wrote each cell, all the algorithm did was decide which order they get played in."[21] Thus, in the past the computer was employed to perform types and quantities of calculations which "would be unthinkable by any other means" in order to automate the implementation of the human's artistic ideas to his or her satisfaction; because the human ultimately "filters its output through his or her intuition and taste," he still wholly takes credit for the work. However, Iamus creates pieces completely free from human intervention, and there is great discussion around whether or not the computer is truly the sole composer.

Iamus' creators insist that the algorithm is the sole author of the music it produces, but many people look for a human influence behind the profound music they hear. Iamus works completely autonomously, but because the algorithm itself was designed by humans, some believe Vico and Díaz-Jerez ought to be considered partial authors of the music. However, the creators continuously insist on taking zero credit for any of Iamus' pieces, insisting that AI

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[18] Penney.
[19] Penney.
[20] Penney.
[21] Penney.

algorithms like Iamus "are conceived by their designers as autonomous entities that transcend the role of simple human aids and inherit the identity of composers themselves."[22] Díaz-Jerez, "perhaps, the primary influencer of Iamus' music," always underplays his influence in the music that Iamus composes: "we've just told the computer some very general technical things."[23] Indeed, Iamus has been presented as independent of humanity, however, this is an unsettling idea. To many people, "the human composer is the ultimate vehicle of artistic ingenuity, deserving of our admiration and praise," so they subconsciously want to know or believe that there is a human being behind the music they hear. Thus, searching for a human life to take responsibility, some say the creators are indirectly the composers of Iamus' creations because they "still remain directly responsible for Iamus' compositional parameters."[24] All in all, there is a struggle to draw the line between computer-aided composition and autonomous AI composition and to determine what happens to human agency in the process of algorithmic composition: "What is the essential difference between Mozart and Iamus, and at what point, if at all, does the human author disappear from frame?"[25] Furthermore, through people's scrutiny of Iamus' music upon learning that the sounds were artificially created, we surmise that this desire to give human authorship to a work made completely by a machine is a result of humanity's need for its art to hold authentic human intention.

Listeners find the music technically impressive and enjoyable until they discover the music was artificially generated, at which point they change their opinion because they do not believe an algorithm can portray or inspire human emotion. When people listen to Iamus' works

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[22] Penney.
[23] Penney.
[24] Penney.
[25] Penney.

completely unaware that the music was created wholly by a computer, the majority enjoy the music. When musicologist Peter Russell first heard Iamus' score *Hello World* he was "pleasantly surprised," describing it as "a delightful piece of chamber music reminiscent of French pieces written in the early 20th Century."[26] Russell, like many listeners who have been similarly fooled in blind tests, was unaware that the music had been composed by a computer cluster.[27] But, when many of these fooled listeners find out that the source of the composition is not a human, "their opinions quickly turn negative." As Doctor David Cope found, "when they assume the music is human, they describe the emotions unleashed by the music and speculate on what the composer was trying to say. But after I tell them that there is nothing behind the music but cold hard machinery doing addition and subtraction they won't admit they were moved."[28] In other words, the ignorant listener enjoys the music, believes there to be intention behind it, and find that it provokes their human emotions, but because we intrinsically want music to come from a place of human intention, listeners completely change their minds upon learning that a machine produced the work. This illustrates people's unconscious prejudice against artificially composed music.[29]

This unconscious prejudice demonstrates something about the way humans perceive artificial intelligence: even though a machine may be so adept at mimicking human intelligence that it can replicate human intention and provoke human sentiment, if there was not a human directly behind the music with this intention, then the music loses all worth, all meaning, and all artistic quality. Most people can not distinguish between humanly composed music and Iamus' works, and most enjoy the artificially generated scores, meaning the machine has mastered the

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[26] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[27] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[28] Penney, "Algorithms in Music: Blessing or Curse?"
[29] Ball, "Algorithmic Rapture: Philip Ball Listens in on an Album of Evolved Music Composed by the Darwinian Computer Program Iamus.(COMPUTER SCIENCE)."

ability to not only mimic human intelligence but also human creativity and intention. In other words, Cope's experiments have corroborated that Iamus passes Alan Turing's famous Turing Test which "contends that successfully emulating human activity demonstrates a machine's intelligence as equivalent to or indistinguishable from a human's."[30] But, unlike other machines that pass the Turing Test, used perhaps in the fields of science or math, in this case the human intelligence that Iamus is replicating is a creative and aesthetic intelligence; Iamus is mimicking the human ability to create profound music that portrays some emotion of the human experience. Iamus brings artificial intelligence into the realm of art, and for this reason, its ability to create work almost indistinguishable from a human counterpart is not received entirely positively by members of its field.

Music is a form of art, and thus, like any art, its purpose for existence is as a vehicle for human artists to share some aspect of their own unique human experience with the world and for the human audience to understand another humans emotions and feel those same emotions within themselves. Thus, at the core of all art is the artist's intention to provoke human sentiment. While Iamus is programmed with the intention of and clearly capable of provoking human sentiment, since it is not a human with a conscious intention of representing their struggles, love, fears, and experiences through music, people no longer find value in the works upon discovering they were composed inhumanly. In other words, "definitions of art often center on its innate humanness" and on "the journey, intentions, creative and production objectives of the artist." So, to many, "this is not art. It's only generated tones. the computer [has] no intention or consciousness of what he is doing."[31] Once people realize it was not a human that peaked their

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[30] Penney, "Algorithms in Music: Blessing or Curse?"
[31] Penney.

emotions but rather a computer who has been taught to mathematically calculate music that peaks their emotions, the music no longer moves them emotionally. As one listener remarks, "an algorithm can mimic a human nowadays, but unless it demonstrates awareness of its own intentions, it is simply another sophisticated human tool."[32] Peter S. Langston, a computer programmer with extensive background in algorithmic composition, adds, "while many algorithms appear to compose music that contains semantic/emotional content, it is purely coincidental seeing that algorithms themselves have no information about human emotions."[33] All in all, Iamus' music is undeniably impressive and human-caliber, but because it comes from an immortal place, it isn't appreciated as much as if it were humanly made: "I've listened to the music of Iamus, and I don't like it, although I do think the effort is important, and technically impressive. It may have scales, but it's a boneless fish, flopping about without real purpose, going nowhere, without motivation, without awareness of itself, without any desire to provoke or caress, and without love."[34] Thus, our strong, pre-established ideologies about what we believe art should be, revolving around the concept of a unique, identifiable human creator "leads many to reject algorithmically-generated music to some degree," creating a bias (conscious or not) against non-human created music.[35]

Thus, since humanity can not yet accept the concept of computers replicating human intention and creativity, we should not expect many musicians to listen to or preform Iamus' works in the near future; however, musicians should take advantage of Iamus' ability to create new classical musical styles and hybrid-genres, using at a brainstorming tool to expand the

[32] Penney.
[33] Penney.
[34] Penney.
[35] Penney.

horizons of classical music. It is an extremely thought-provoking and somewhat frightening concept that a computer could, without any human experience of its own, incite deep, profound emotion within us. We have always known that computers were capable of computational processes that were impossible to man, but man has held a "unique claim to creativity," maintaining art as something innately human, something that requires a creativity and intentionality that no computer could be taught.[36] Iamus, in its ability to "display human characteristics" and to "simulate and thus stimulate emotionality," changed this.[37] The reason people are hesitant to embrace Iamus is that we see art as a vehicle for human communication and connection—art is not art if the artist isn't human—so Iamus' works are not art; as one listener remarked, "the only artist here is the guy who [made] this algorithm. He had an intention of creativity, and probably wanted to express his love with technologies."[38] So, it is unrealistic for Iamus' creators to hope for their algorithm to be widely accepted and appreciated. However, musicians should still utilize Iamus' truly unique ability to invent new musical styles, thinking of Iamus as a brainstorming tool that may inspire them to compose their own music. Musicians can extract some of the interesting new styles and rules Iamus implements in creating their own music. In this way, the field of music still gets to experiment with new musical ideas but the result it more widely accepted because the creations were still driven by human aesthetic decisions and have authentic human emotion behind them.

The creators, too, believe that these new musical rules Iamus can create may be computer cluster's greatest benefit to musicians today. Vico says that "the possibility of generating new

[36] Ball, "Algorithmic Rapture: Philip Ball Listens in on an Album of Evolved Music Composed by the Darwinian Computer Program Iamus.(COMPUTER SCIENCE)."
[37] Ball.
[38] Penney, "Algorithms in Music: Blessing or Curse?"

forms of music [through Iamus], perhaps by blending the rules of existing genres, is one of the prospects that excites him most," and that "Iamus' ultimate value might not be so much as a composer in its own right but as a factory of musical ideas, which human composers can mine for inspiration."[39] In this way, Iamus would focus less on its identity as an autonomous music maker and become more like a tool for 'Computer-Aided Algorithmic Composition' as previously mentioned. This would surely make Iamus less controversial and allow more musicians to reap the benefits of Vico's algorithm. Music critic Tom Service agrees that Iamus' purpose should not be to generate typical sounding music at all, but rather to try to generate completely new musical concepts: "Iamus' creators are making a mistake by programming it to generate music like that of human composers, using the same repertoire of traditional orchestral sounds, rather than seeing whether it can produce music that is more genuinely novel."[40] Thus, for now, people do not need to see or admit to seeing the value in Iamus' autonomously composed pieces, but they should see the value in its capability to expand the horizons of classical music through new styles.

Overall, Iamus represents a monumental leap from algorithms that simply assisted in the composition process to a completely autonomous system that can not only create profound musical scores that replicate human creativity and intention, but also can invent new styles and genres of classical music. The musical pieces Iamus creates without any human intervention reflect an amazing new capability of AI systems to mimic human characteristics and incite emotion in human beings. However, the idea that a machine could authentically replicate these human characteristics—the idea that a computer can be an artist—is an extremely controversial

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[39] "BBC - Future - Artificial Music: The Computers That Create Melodies."
[40] "BBC - Future - Artificial Music: The Computers That Create Melodies."

one. Perhaps the mindset of the general population around this idea will change in the future, but for now it seems Iamus' greatest advantage to musicians will be not its ability to mimic human intention and creativity all on its own, but rather its ability to brainstorm completely unique rules for musical composition that lead to undiscovered hybrid-genres and styles within classical music.

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