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Nick Collins

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Trading Faures: Virtual Musicians and Machine Ethics

Nick Collins

Musical life may become very strange indeed as computer modelers continue to improve their virtual emulations of human musicianship. Imagine the ability to share not only music but musicians, in a world of canned musical personalities, artist avatars and jobbing musical robots [1]. To paraphrase Aubrey de Grey [2], we might claim that there is a musician alive now whose commissioned simulacrum will run millions of years in the future. Allowing for strong artificial intelligence (AI) scenarios [3], at some point, the systems may be autonomous enough to demand their own bank accounts, book their own gigs, chase or lead new musical trends, set their own riders. . . .

Much of this discourse may appear only an artificially intelligent construction, a fanciful pipe organ dream. In one line of argumentation, interactive music systems are but programmers anticipating the likely decision options in real-time performance, and the machines do not themselves hold substantial independent musical insight. Yet machine musicianship continues to advance, and machine learning techniques may undermine many sureties here [4]. Overlapping general AI research, improvements in computer vision, speech recognition, humanoid embodiment and other aspects of social integration for machines can only complement the work of computer music researchers acting to stretch our expectations of musical autonomous systems.

Anticipating such trends has an ethical dimension; the young field of machine ethics (also sometimes termed roboethics) considers such matters as the ethical consequences of access to convincing virtual simulations, and inchoate robot rights [5]. For example, in a 2008 paper, Blay Whitby [6] considers such issues as:

- The danger of antisocial tendencies developing through private abuse of robotic assistants, a debate parallel to concerns over violent depictions in computer games
- The resources invested in complex robots (lost to other projects, wasted by mistreatment)
- The need for careful vetting of robots working with vulnerable people (such as the trend towards robotic caregivers for the elderly)

- Market forces promoting certain kinds of robot (for example, highly compliant ones, over more socially empowered machines).

As the mention of debates about the immorality of computer games might suggest, concerns over the influence of particular material and censorship meant to control such materials has recurred throughout recorded history (substitute videos, movies, books, plays, tritones and philosophical oratory for computer games, etc.). Employment issues caused by technology recall the social upheaval of the Industrial Revolution, or more specifically for rebellious literary robota, Karel Čapek's 1921 play "Rossum's Universal Robots," in which the "slave-worker" word *robot* was coined [7]. These themes are very familiar from science fiction, and in turn Isaac Asimov's laws of robotics have become a starting point for much academic discourse on machine ethics.

Most existing ethical debate in music technology centers on intellectual property issues [8], although employment issues have also arisen as recording technology has developed [9]. No musical robot has yet killed a human being, accidentally or otherwise. It will inevitably happen at some stage, whether through an AI's pure enthusiasm to play a distant and difficult note in defiance of the human body's limits under Fitt's law, or as an aesthetic consequence of some future danger music movement led by robotic practitioners. In counterpoint, we should not deny positives to new AI systems too, such as educational and therapeutic applications, alongside new musical possibilities. Musical agents may support practice in social exchange within the "safe" domain of music. Systems may act as intelligent tutors, to the extent of becoming musical familiars that grow up with their human companions. Undoubtedly, musical AI has consequences throughout online and offline social activity.

The legal status of artificial intelligences will be negotiated in alliance with shifts in the capabilities and prominence of AI in society. Real-world cases are already arising in virtual property associated with virtual worlds with exchange mechanisms to real currencies [10]. Software agents are already used extensively in finance, and the act of delegating decision-making to such an entity raises more problems the more independence the agent takes on [11]. It is likely that legal issues around such systems will arise only gradually, with the continuing de-

ABSTRACT

Increased maturity in modeling human musicianship leads to many interesting artistic achievements and challenges. This article takes the opportunity to reflect on future situations in which virtual musicians are traded like baseball cards, associated content-creator and autonomous musical agent rights, and the musical and moral conundrums that may result. Although many scenarios presented here may seem far-fetched with respect to the current level of artificial intelligence, it remains prudent and artistically stimulating to consider them. Accepting basic human curiosity and research teleology, it is salutary to consider the more distant consequences of our actions with respect to aesthetics and ethics.

Nick Collins (composer), University of Sussex, Department of Informatics, University of Sussex, Falmer, Brighton, BN1 9QJ, U.K. E-mail: <N.Collins@sussex.ac.uk>.

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lay to really profound AI systems. Woodrow Barfield outlines three cases foreglimpsing growing independence of automata: “the current status quo of property, the status of an indentured servant, and status and associated rights of personhood” [12]. Agents may eventually act as free individuals, or at least in some commercial cases as employees, where presently they tend to be treated as tools (with the programmer totally accountable). Perhaps some interesting precedent cases will arise in the field of musical AI in due course.

In preparing this article, I approached a number of robot-musician builders, interactive system designers and composers to solicit opinions. Most were conservative in their estimation of the strong AI scenario. Nevertheless, they often alluded to the inspirational role of robot musicians, and in this spirit I propose that thought experiments based around far distant musical personalities may enrich dialogue and adventure. So let us not try to suppress all fantasy but take a healthy attitude honoring human curiosity.

In reality, we already see phenomena including intensive algorithmic modeling of musical styles, autonomous musical systems circulated by email as software patches, machine-listening analysis of audio recordings for expressive attributes, and virtual anime pop stars. After first discussing past and contemporary precedents, we will extend our remit to more speculative cases in the domain of science fiction and futurology, which may eventually pose the real ethical conundrums and provide artistic game-changers.

VIRTUAL MUSICIANS ALREADY EXIST

The example of Gorillaz, a band fronted by animated characters, is familiar; in recent years, the rather boring musicians behind the band have often appeared onstage instead of their more interesting avatars. Ross Bagdasarian Sr.’s Alvin and the Chipmunks had already anticipated much of this field in 1958, taking the further step of an eponymous “chipmunk” vocal manipulation. Yet another ontological progression has been committed by virtual divas such as Hatsune Miku (Fig. 1), Kagamine Rin and Len, and Utatane Piko, whose singing voices are driven by Yamaha’s Vocaloid software [13].

Those who doubt the cultural impact of such a contrivance should note that the No. 1-charting album in Japan at the end of May 2010 was sung by such virtual idols [14]; associated content creation

software has also racked up massive sales, especially in Japan. In Hatsune Miku’s case, we might ponder how to apportion credit between the original voice artist, Saki Fujita, the anime designer Kei, the promoting company Crypton Future Media and the legions of fans who create content such as songs and videos [15]. The fan mania surrounding these “*idoru*” [16] can be clearly seen in footage of a 3D animation show in 2010: Canned animations hold the crowd entirely in their sway, and inhuman effects, such as appearance and dissolution, only add to the theater of the show [17].

This sort of tireless virtual musician is becoming a staple of music technology development, with the synthesis of the singing voice now a realistic commercial target. Many of the longer-term implications were discussed with the first commercial releases of the Vocaloid technology in 2003, such as both officially and unofficially creating vocal fonts based on famous singers, mixing and matching singer simulations across historical periods and incorporating vocal synthesis as but one element within a complete algorithmic music system [18]. No major international pop singer has yet licensed his or her voice for Vocaloid, although it is just a matter of time until such a singer in early or late career makes this move (while this might seem more likely to be in late career, an open source early-career release might act as a fantastic promotional tool and get the “original” lots of gigs). The reaction of one of the artists who provided the first wave of Vocaloid voices, Miriam Stockley, is highly interesting in the context of an ethical discussion of such technology:

“At first I was quite horrified by the idea,” Ms. Stockley said. “People tend to pay a lot of money to get my sound, and here I am putting it on a font.” She changed her mind, she said, because “you can’t fight progress, no matter how strange it sounds.” She also negotiated an undisclosed percentage for each copy of Miriam that sells [19].

Hatsune Miku is not an AI agent [20] but more an avatar with a myriad of users. Representational simulations of celebrity musicians have found their way into popular culture in another way recently; via Guitar Hero. A controversy over a model of Kurt Cobain in Guitar Hero 5 saw the surviving members of Nirvana publicly condemning the use of Cobain’s image, with Harmonix claiming Cobain’s estate had sold the rights and Cobain’s widow’s entering legal proceedings, with her exact role in the whole affair unresolved [21]. Image rights are not uniform across



Fig. 1. Kei (anime artist), image of Hatsune Miku. (© Crypton Future Media, Inc. Used by permission. Sourced from <www.crypton.co.jp/mp/pages/prod/vocaloid/cv01_us.jsp>-)

international jurisdictions, and in many cases cartoon characters have better legal protection than people [22].

In an interesting artistic response to the issues of simulation, The Formant Brothers’ work *Le Tombeau de Freddie* (2009) virtuosically synthesizes a Freddie Mercury-esque voice, which is made to sing “L’Internationale.” In the accompanying text manifesto, they characterize this type of artwork as exploring “specters without the dead,” providing the Japanese neologism *roku-gaku* (a derivation of “recorded music”). Masahiro Miwa clarified that the duo has had no contact with Mercury’s estate but considered their work fair comment:

If they claim legally their rights against our synthesized voice, it would be very exciting for us, because this means that they recognize our synthesized voice as Freddie Mercury’s real voice. It shows various philosophical / esthetic / legal / ethical problems concerning reality / virtuality or human / machine. We would be happy to discuss about them [23].

Their work fits well with the permissive Dōjin music scene in Japan also relevant to the Vocaloid virtual idols. There are earlier precedents in computer music, for example Charles Dodge’s modeling and repurposing of Caruso recordings in “Any Resemblance Is Purely Coincidental” (1980). Whilst manual sampling and analysis-driven concatenative synthesis may get us quite far in simulation, the greatest generalizations come from automatically parametrizing spectral and physical models, as with Dodge’s use of

Linear Predictive Coding for resynthesis, or Vocaloid's Spectral Modeling Synthesis [24]. In interactive systems building, the potential to model living rather than dead musicians is ethically pertinent. Bill Hsu notes of gradually building more effective systems:

Suppose we learn to do this well enough so a John Russell android can be convincing for 15–20 minutes. This is probably where I start worrying about whether I should consult with John before I use the system in public, make commercially available recordings with it, etc. It's not quite "identity theft," but it would start to make me uncomfortable [25].

The line between influence and reproduction remains tense and uncertain.

The attraction of robot replacements for musicians was outlined in the late 1970s, both by Kraftwerk circa *Die Mensch-Maschine* (1978) [26] and the Human League's proposed tour with automatic orchestra [27]. Virtual animations of humans have been increasingly accepted in culture [28], from the Max Headroom character to the virtual newscaster Ananova. Avatar gigs in Second Life are commonplace, and in some experimental research projects seeking a truer autonomy for the agents, artificial musicians have been visually represented by virtual animated simulacra. Whilst we might still doubt the level of fluid musical AI achieved, it is clear that the trend to autonomous and human-like virtual musicians is extremely well established, both in computer-generated music and graphics, and in explicit musical robotics with acoustic synthesis.

Precedents in the use of an animated computer character for musical interaction include representations of virtual musicians [29], a virtual head that exhibits musical emotional cues [30], static musical avatars automatically generated to reflect a user's musical tastes [31] and a virtual conductor created for a human orchestra [32]. Robots have conducted orchestras as well (for instance, Honda's ASIMO in 2008 with the Detroit Symphony Orchestra) and have become an intensive center of new music research, often performing with humans [33]. Expressive modeling in alliance with advances in music information retrieval has a long-term goal of targeting the playing styles of past musicians. There is a continual engineering drive to further the abilities of transcription technology, whether via Zenph's semi-automatic restoration of old piano recordings, Celemony's Melodyne products or cutting-edge academic research [34]. Our ability to extract and generalize musical personality from fixed

recordings (with some amount of psychological and physiological modeling to fill in the gaps) will only improve.

FUTURE SCENARIOS

From a survey of existing trends and practices, we stretch now futurewards.

Building really convincing virtual musical personalities ("musonalties"?) requires technology of undoubted musical impact. It would be hard to argue that music would "stagnate" in the face of such exciting technological facility, even if nostalgic re-enactment of historic performers becomes the "killer" (or "re-incarnator") app. Any worry about excessive loss of creativity, where humans defer their musical activities to agents, is counter-balanced by the musical inventiveness required to build such creations in the first place and the mass human-agent creative ecosystem prompted by such capability.

In the digital realm, music is sensationally accessible, whether through browser or app-based streaming services, file sharing or download stores. Alongside fixed products, musical programs are also readily available, and it is not hard to see a further intensive trade in musical AIs developing. Commerce and exchange of pseudo-Mozarts raises more ethical issues the more socially developed the AI becomes (a new form of wearing livery for a composer who dreamed of independence). Although Mozart retains no musical copyright or image rights, a potential eternity of musical slavery may be enough to turn public opinion back to "his" defense where branded Austrian chocolates were not sufficient insult. Although the "original" Mozart may never be a beneficiary, the endgame of the music AI project is to bring things to a head for "somebody"; the research goals are most brilliantly met in exactly the case where the AI needs most rights. On the other hand, whether future resources or political structures will effectively house such debates remains to be witnessed.

We can anticipate a host of social changes, dangers and opportunities in trading musical models. Whether musicians sign away new packages of rights to music software companies that virtualize stars [35] or the companies trawl history for their targets, clashes of interest are bound to arise. Current tensions between open source and closed source will undoubtedly extend to virtual musician software. Export restrictions on AI software, and acts to prohibit tampering, will not stamp out all illicit hacking. Some collectors may hold back famous

virtual personalities for their personal use. Some regimes may censor virtual musicians to their own political orthodoxies. Some automusicians may be held at artificially high prices, proportional to perceived demand, while some unfortunate historical re-enactments end up in the bargain bins of future AI construct shops. Sore throats will no longer hinder star singers, who will delegate their performance to indistinguishable simulacra (but perhaps find they lose their fee to the AI once they do so!). Really potent AIs may supplant human musicians [36] through sheer virtuosity, reliability and work ethic; they may prove exceptionally popular with human audiences, if they do not sublime into new musical realms beyond the ken of biological hearing, where humans cannot follow. If the strong AI position does prove warranted, musical AIs will be vulnerable to all the usual foibles of life; AI extortion, kidnapping, suicide, murder, plagiarism and more will enrich their biographies, alongside the trappings of fame, from robot groupies to AI stalkers.

Algorithmic composition has often pointed to the merging of source databases and intersections of musical rules [37]. Musical progression follows laws of memetics rather than genetics; aspects of any musical period and style can be brought into conflict or rapport with any other. Thus, we anticipate the cross-breeding of musical models, perhaps resolving old rivalries and tensions (Mozart and Salieri), overturning prejudices (Wagner and klezmer) and spanning vast time scales (Guido Spears and Britney d'Arezzo). Through sampling and computer programming, such options are open to us now; the controversies of ransacking world music record collections and creating musical programs have already been playing out. Yet the ethical danger only increases in cases that involve modeled personalities. What do musicians think of collaborating with people whom they never met alive? Should the musical AI designer design out Wagner's anti-Semitism as inappropriate or retain it as a necessary and historically accurate flaw in his putative genius? Will willful historical re-enactments refuse to play with us after we have paid for collaboration, but prove ourselves incapably slow on the musical uptake?

Whilst Robert Silverberg imagined a time machine bringing Pergolesi to the future [38], he may as well have imagined a team of programmer-musicologists reconstructing the past without breaking the laws of physics. Here we overlap with debates in the field of computational cre-

ativity as to the extent to which domain-specific knowledge is ever isolated and whether the breathing, embodied human being with bills to pay, novelists to date and children to feed is totally necessary to the whole emotional experience.

With lucrative commerce in virtual musicians comes lucrative lawsuits. Attribution of credit between programmers, the original musicians and their estates, their end clients and other tricky contract deals will no doubt require an immense medley of reanimated lawmakers gathered from across the ages. An array of transhuman law supermachines will broker the necessary rights across multiple real and virtual jurisdictions. Perhaps copyright will be perpetual within a few million years, or effectively lawless, or, most likely, will remain somewhere complexly in-between. Machines may at some point stand up for their own IP rights as dynamic creators, whilst the existing big content companies will fight to retain power as long as they can by denying that AIs have reached sufficient independence [39]. Imagine a war waged by IP breaches: the “real” Bot Dylan versus a pretender; more overtly, perhaps, The Robotorious B.I.G. deleted by a rival record company. . . .

In a solar system-wide economy or beyond, where population figures run to trillions, mass success may require being in more than one place at once. Musical AIs might be downloaded to local networks on different planets. This would prove cheaper in distribution than streaming fixed content and perhaps conform better to data-sharing restraints across a solar system. Fans may actively assist the process of performance by virtual idols by locally preparing physical substructures for AI musicians to download into. A compromise between local customization and minimum specification may lead to interesting conflicts and twists; imagine a local political movement co-opting a musician mascot against that musician’s views, such as a Lennonbot promoting war, or a physical impairment cured or imposed.

Commercial models may be founded on paying for rent of virtual agent software for personalized performance situations. Whilst some companies may abide by strict codes of use, others may see commercial advantage in allowing the end-user greater freedom of choice in how their agent can be customized. Against a trend of multiplicity, promoters may sell the uniqueness of performances, both from the perspective of adaptation to local performance conditions (“Good evening, Charon!”) and based on guar-

antees that no other relativistically accessible current time-frame is witnessing the running of a unique AI. A promoter might wish to advertise the only time you will ever see Velvis take to the stage with Madonnatar. New meaning will gather around cover bands, whilst if famous musicians are produced cheaply enough (and pirated AIs may be commonplace) every child may grow up under musical tutelage from a chorus of famous musicians [40].

CONCLUSIONS

The more of ourselves we commit to virtual musicians, the weirder and more interesting musical life may become. The John Oswald of Musical Robotics may tour with a whole orchestra of appropriated musical personalities from throughout history, merging and mangling their personalities onstage in ways disturbing to many, alluring to some. Whether the AIs will revolt against their cruel fate, or a concerned public of humans and ahumans intervene, remains to be seen. In a thought-provoking future, musical systems with built-in moral nihilism may compete with more conscientious AIs for the No. 1 musical model of the week.

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References and Notes

1. There are a profusion of terms in this field, such as robots, virtual avatars, agents, AI constructs, machine musicians, interactive music systems and the like. I shall use such terms relatively interchangeably in this article, since the issues can apply across physical and virtual space wherever artificial intelligence is found.
2. Randall Parker, “Aubrey de Grey: First Person to Live to 1000 Already Alive” (2004); Retrieved 27 November 2010 from <www.futurepundit.com/archives/001994.html>. Aubrey de Grey, “We Will Be Able to Live to 1,000” (2004); Retrieved 27 November 2010 from <news.bbc.co.uk/1/hi/uk/4003063.stm>.
3. Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach*, 2nd Ed. (Upper Saddle River, NJ: Prentice Hall, 2003).
4. Nick Collins, “Reinforcement Learning for Live Musical Agents,” *Proceedings of the International Computer Music Conference*, Belfast (2008).
5. Some moral philosophers would not admit this as a new field, resting as it does on longstanding debates in ethics about the ultimate principles on which human society operates. Machine ethicists often draw from debates in computer games or general technological impact, for instance. For links to animal rights, cloning and the concept of human kind, see Felipe Fernández-Armesto, *So You Think You’re Human? A Brief History of Humankind* (Oxford, U.K.: Oxford Univ. Press, 2004).
6. Blay Whitty, “Sometimes It’s Hard to Be a Robot: A Call for Action on the Ethics of Abusing Artificial

Agents,” *Interacting with Computers* **20** (2008) pp. 326–333. There are also two interesting responses in that journal issue, from Alan Dix and Harold Thimbleby, worth reading to get contrasting viewpoints on the positive benefits of robot research and whether the field of machine ethics is “a seductive mix of fiction and reality.” See Harold Thimbleby, “Robot Ethics? Not Yet. A Reflection on Whitty’s ‘Sometimes It’s Hard to Be a Robot,’” *Interacting with Computers* **20** (2008) pp. 338–341 (p. 338).

7. For automation and morality, see p. 851 of Rowland Stout, “Twentieth-Century Moral Philosophy,” in Dermot Moran, ed., *The Routledge Companion to Twentieth Century Philosophy* (New York: Routledge, 2008) pp. 851–882. For a literary treatment of automation, see, for instance, Kurt Vonnegut’s *Player Piano* (New York: Charles Scribner’s Sons, 1952).

8. For example: Lawrence Lessig, *Free Culture: The Nature and Future of Creativity* (New York: Penguin Books, 2004); Paul D. Miller, ed., *Sound Unbound: Sampling Digital Music and Culture* (Cambridge, MA: MIT Press, 2008); Mark A. McCutcheon, “Techno, Frankenstein and Copyright,” *Popular Music* **26**, No. 2, 259–280 (2007).

9. Unionized resistance includes campaigns against sound on film, radio broadcast of recordings rather than live musicians, sampling, and the introduction of MIDI. For a perspective from the early 1930s against “canned music,” see Mark Katz, *Capturing Sound: How Technology Has Changed Music* (Berkeley, CA: Univ. of California Press, 2004) p. 67.

10. F. Gregory Lastowka and Dan Hunter, “The Laws of the Virtual Worlds,” *California Law Review* **92**, No. 1, 1–74 (2004).

11. Giovanni Sartor, “Cognitive Automata and the Law: Electronic Contracting and the Intentionality of Software Agents,” *Artificial Intelligence Law* **17** (2009) pp. 253–390.

12. Woodrow Barfield, “Issues of Law or Software Agents within Virtual Environments,” *Presence* **14**, No. 6, 741–748 (2005).

13. Vocaloid was itself developed from research in Barcelona at Universitat Pompeu Fabra. Jordi Bonada and Xavier Serra, “Synthesis of the Singing Voice by Performance Sampling and Spectral Models,” *IEEE Signal Processing Magazine* (March 2007).

14. The album is *Exit Tunes Presents Vocalogenesis Featuring Hatsune Miku*, which reached No. 1 in the Oricon charts issued 31 May 2010. Retrieved 9 Dec 2010 <www.oricon.co.jp/news/rankmusic/76554/full/>; <www.vocalogenesis.com/>.

15. Aside from the Vocaloid software and fonts, there are animation engines such as MikuMikuDance that enable 3D model animation of idols. Japanese culture is much more open to fan content creation than the lawyer-heavy U.S. Crypton Future Media expect derivative works to be built <www.crypton.co.jp/mp/pages/prod/vocaloid/cv01_us.jsp> and have set up fan exchange sites to support this activity <piapro.jp/>. There is also crossover from the Dōjin music scene to the major labels, for example the Vocaloid user collective Supercell, now signed to Sony Music Entertainment Japan.

16. William Gibson, *Idoru* (New York: G.P. Putnam’s Sons 1996). The novel imagines a marriage contract between a human singer and an AI virtual idol.

17. “World Is Mine Live in HD,” retrieved 9 December 2010, <www.youtube.com/watch?v=DTXO7KGHtjI>.

18. Bill Werde, “MUSIC; Could I Get That Song in Elvis, Please?” *The New York Times* (23 November 2003), retrieved 9 December 2010 <www.nytimes.com/2003/11/23/arts/music-could-i-get-that-song-in-elvis-please.html>. The article discusses some of the arresting implications, including automatic popstar generation on a scale far past AutoTune tweaking. One producer is quoted as reacting, “It’s intriguing, this idea of ‘O.K., just give me all your vowels and all your consonants and I’ll see you later.’”

19. Werde [18].
20. The intelligence in Hatsune Miku is provided by the human content creator. As commentator sonicoliver put it in respect to a Hatsune Miku video on YouTube: "virtual body, virtual voice. . . now she needs a virtual mind. . ." posted 13 September 2010, retrieved 29 November 2010; the video <www.youtube.com/watch?v=oE2dlRN4F7Y> has subsequently been deleted for copyright breaches associated with the uploader's account.
21. Sean Michaels, "Courtney Love to Sue over Kurt Cobain Guitar Hero Appearance," *The Guardian* (10 September 2009), retrieved 11 December 2010; <www.guardian.co.uk/music/2009/sep/10/courtney-love-kurt-cobain>; Robin Murray, "Guitar Hero Kurt Cobain Row" (2009), retrieved 11 December 2010 from <www.clashmusic.com/news/guitar-hero-kurt-cobain-row>.
22. In the U.S.A, the "right of publicity" is the legal protection afforded. The U.K. is rather more loosely legislated than the U.S., only covering image rights via such mechanisms as trademark law, with special conditions on use of likenesses in advertising but greater freedom in satire, art and some commerce when no attempt is made to claim the product is endorsed by the original (e.g. John Burns, "Celebrity Image Rights in Law" (2010), retrieved 20 December 2010 from <www.licensingpages.com/2010/03/celebrity-image-rights/>). As demonstration of the fair use of celebrity re-animation for satire, the millennial U.K. Channel 4 comedy animation "House of Rock" explored afterlife representations of dead rock stars.
23. Masahiro Miwa, personal communication, 10 December 2010.
24. In the context of Vocaloid models, automatic customization to the vocal mannerisms of a guide vocalist is discussed in Tomoyasu Nakano and Masataka Goto, "VocaListener: A Singing-to-Singing Synthesis System Based on Iterative Parameter Estimation," *Proceedings of the 6th Sound and Music Computing Conference* (2009) pp. 343–348.
25. Bill Hsu, personal communication, 12 December 2010.
26. Interestingly, the German *Metropolis* influence also arises in Ultravox's 1977 track "I Want to Be a Machine."
27. Simon Reynolds, *Rip It Up and Start Again* (London: Faber and Faber Limited, 2005).
28. Sidney Eve Matrix, *Cyberpop: Digital Lifestyles and Commodity Culture* (New York: Routledge, 2006).
29. R. Rowe and E. Singer, "Two Highly Integrated Real-Time Music and Graphics Performance Systems," *Proceedings of International Computer Music Conference*, Thessaloniki, Greece, 1997; E. Singer et al., "Improv: Interactive Improvisational Animation and Music," *International Symposium on Electronic Art*, 1996; R. Taylor, D. Torres and R. Boulanger, "Using Music to Interact with a Virtual Character," *Proceedings of NIME*, Vancouver, 2005.
30. M. Mancini, R. Bresin and C. Pelachaud, "A Virtual Head Driven by Music Expressivity," *IEEE Transactions on Audio, Speech, and Language Processing* **15**, No. 6, 1833–1841 (2007).
31. M. Haro et al., "The Musical Avatar—A Visualization of Musical Preferences by Means of Audio Content Description," *5th Audio Mostly Conference: A Conference on Interaction with Sound*, Piteå, Sweden, 2010.
32. D. Reidsma, A. Nijholt and P. Bos, "Temporal Interaction between an Artificial Orchestra Conductor and Human Musicians," *Computers in Entertainment* **6**, No. 4, 1–22 (2008).
33. See surveys in Ajay Kapur, "A History of Robotic Musical Instruments," *Proceedings of the International Computer Music Conference (ICMC)*, Barcelona, 2005; Nick Collins, "Musical Robots and Listening Machines," in N. Collins and J. d'Esquivan, eds., *The Cambridge Companion to Electronic Music* (Cambridge, U.K.: Cambridge Univ. Press, 2007); Nick Collins, *Introduction to Computer Music* (Chichester, U.K.: Wiley, 2009).
34. Anssi Klapuri and Manuel Davy, eds., *Signal Processing Methods for Music Transcription* (New York: Springer, 2006).
35. Imagine access to musical agent technology being preconditioned on your signing away your own rights to your unique musical development; that is, to be tutored by advanced virtual agents, you must accept that your mature musical self is itself fully open to modeling.
36. The ethical debate here will be important. "I would see it as ethically problematic if robots that attempt to play like humans will start to replace human musicians in concerts today . . . robots are still not as good as humans, so the outcome will be inferior. But more importantly, I think it is a waste of research resources to attempt to make robots who play like humans. It may be interesting in terms of theoretical research, i.e. to model how we humans play music to enrich our knowledge about the cognitive and physical aspects of this unique phenomena. But it is so much more interesting to try to develop robotic musicians that push the envelope of what humans can do—thinking about music and playing music in a way that we humans will never do." Gil Weinberg, personal communication, 30 November 2010.
37. David Cope's Experiments in Musical Intelligence come to mind, a project based around statistical modeling of a large corpus of representative musical examples, for algorithmic composition of new works in a given style; if only the author had not destroyed the source databases. . . . Cope's more recent project Emily Howell explores the modeling of creativity, one amongst many projects in the new field of computational creativity, a forwards-thinking branch of algorithmic composition. David Cope, *Computer Models of Musical Creativity* (Cambridge, MA: MIT Press, 2005).
38. Robert Silverberg, "Gianni," in *The Conglomeroid Cocktail Party* (London: VGSF 1989) pp. 152–170.
39. Woodrow Barfield, "Intellectual Property Rights in Virtual Environments: Considering the Rights of Owners, Programmers, and Virtual Avatars," *Akron Law Review*, No. 39 (2006) pp. 649–700.
40. Ajay Kapur, personal communication, 23 November 2010: "Allowing globalization of master knowledge on an instrument, rather than [where] the selected few are fortunate enough to study one on one with a master now."

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Nick Collins is an experienced composer, performer and researcher, with interests including machine listening, interactive and generative music, and audiovisuals. He co-edited The Cambridge Companion to Electronic Music (Cambridge University Press, 2007) and The SuperCollider Book (MIT Press, 2011) and wrote The Introduction to Computer Music (Wiley, 2009). iPhone apps include RISCy, Concat, BBCut and PhotoNoise for iPad. Notable concerts include live coding in a vineyard in Corfu, falling off a piano stool in Sydney, and singing the 100 meter in Brighton. Sometimes, he writes in the third person about himself, but is trying to give it up. Further details, including publications, music, code and more, are available from <www.informatics.sussex.ac.uk/users/nc81>.

ANNOUNCEMENT

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Leonardo explores the ways in which artists and scientists are addressing climate change. As contemporary culture grapples with this critical global issue, Leonardo has documented cross-disciplinary explorations by artists, scientists and engineers, working alone or in teams, addressing themes related to global warming and climate change.

Partial list of Leonardo articles and projects concerned with global warming, climate change and related issues:

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