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Communicative and Artistic Machines: A Survey of Models and Experiments on Artificial Agents

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***Abstract*—**Machines can be either tool, media, or social agents. Advances in technology have been delivering machines capable of autonomous expression, both through communication and art. This paper deals with models (theoretical approach) and experiments (applied approach) related to artificial agents. On one hand it traces how social sciences' scholars have worked with topics such as text automatization, man-machine writing cooperation, and communication. On the other hand it covers how computer sciences' scholars have built communicative and artistic machines, including the programming of creativity. The aim is to present a brief survey on artificially intelligent communicators and artificially creative writers, and provide the basis to understand the meta-authorship and also to new and further man-machine co-authorship.

***Keywords*—**Artificial communication, artificial creativity, artificial writers, meta-authorship, robotic art.

I. E-Authoring[1]

IT is possible to trace a history of systemic or meta-writing in the long tradition of 'Ars Combinatoria'. The investigation would necessarily imply a reflection on the articulation of language and thought through different cultural histories. The medieval philosopher Ramon Lull, a Christian acquainted with Jewish and Islamic traditions, is regarded as the first to conceive of an autonomous generative system. Lull produced, in the 13th century, a series of concentric movable wheels considered to be the first textual machines. Giordano Bruno, read Lull in the 16th century, and both were read by Leibniz, inspiring his "Dissertatio of Ars Combinatoria". The literary procedures correlated with 'Ars Combinatoria' also form a line of experiments worth being reviewed. The prose work of Raymond Roussel, the procedures of surrealists and dadaists, the portmanteau words of James Joyce, the movement of Brazilian concrete poetry, the potential literature of the French group Oulipo, the recreated neologisms of Brazilian novelist Guimarães Rosa, the cut-ups of William Burroughs - all demonstrate the richness of the combinatory tool for thought and language experimentation. In the 20th century, Paul Klee and Kandinsky have developed a complex visual vocabulary that would underlie their quite programmed works and teaching strategies. The pedagogical notebooks of Paul Klee represent a complete guide to the use of complex combinatory principles to create visual art.

In the past decades, all those historical visual and textual procedures have been reconceived as elements of an evolutive process, since the emergence of the computer as a semiotic machine able to recombine signs through mathematical algorithms. Those contemporary systems have been providing unheard-of forms of person-computer interaction and co-authorship. The creation, recreation, and recombination of words, phrases, paragraphs, and texts through the continuous development of computer-generated writing entail a new writing methodology and a new research area. It proposes a creative dialogue between the manifested linguistic structures and the possible modifications that computational systems can introduce through algorithms specially designed to work as electronic authors. Those human-machine creative systems have engendered relevant information for scientific and philosophical investigations into the nature of human and machinic perception, expression and intelligence.

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[1] This section is an excerpt from [1].

II. Meta-Authorship

The concept of meta-authorship has been worked by [2] over the last 10 years. The idea involves two main factors: one technological, other sociological. The first factor implies the information and communication technologies (ICT) as a platform for mediated interaction - which stands for the 'meta' part of the equation. The media functions not only as a material intermediary between human agents, but it mostly intervenes through the creative process as well. That explains why some artists have evolved to become 'designers of media systems'. The second factor has to do with the cooperation between agents (the sociological link), who use the media to interact in order to produce texts, images, and sounds. So artists intentionally submit themselves and their potential work to two sources of interferences: other artists (as co-authors) and the media. Interestingly, sometimes the media become the artists' counterpart. For example, when Artificial Intelligence (IA) is able to perform the referred cooperation - with machines and software enacting as effective artistic co-authors. In this case, the media play all the three functions: a tool, an interactive platform, and a social agent. Such an event raises questions over the copyright and creativity of the masterpierce, for instance. Anyway, this cooperation stands for the 'authorship' part of the equation.

The constant transformation of communication media have been requiring new strategies, new planning methodologies for creative production. In consequence, a whole new concept of creative expression has emerged: the designing and scripting of media-based procedures intended for artistic re-invention, a process called meta-authorship. Following this tendency, some authors,

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writers, artists, besides providing new content, have also been performing as designers of media systems. [2]

The point of this paper is partly to discuss how machines can autonomously express themselves by communicating and making art with human partners. That evokes a *continuum* in the history of e-authoring, with contemporary *automata* being capable of writing texts, painting canvas, composing music, and so on. Of course, before bringing examples of real experiments that deliver such performances, it is necessary to register some theoretical models from two types: the ones generated into the communication schools, and the ones originated by the computer scientists. Whenever the latter can surely help to understand the process of meta-writing, there is a hope that the former could shed some light into the meta-authorship dynamics. In any case, those experiments will provide the basis for an original theoretical proposition for historical research, for re-apprehending works of different time periods, and also for the conception of a pedagogical project intended to orient creativity in visual arts, communications and literature.

III. Meta-Writing

The concept of meta-writing is based in a review of the concept of authorship as exercised in recent works specially those combining art and technology. Authorship is seen as a process with, at least, two levels of articulation. The first, called meta-text, acts as a generator, determining the second, the text itself. As the text unfolds it actualizes the meta-text, as an interpreter actualizes a musical score. This understanding of a bisected authorship introduces a new methodology for creative expression. At first, the author establishes a meta discourse, a kind of media partition that plans and directs the operational interfaces between creators, materials, processes, tools, and programs. Those pre-determined principles of procedural, conceptual, technological and computational order guide the writing of the text, that is, the construction of the final work. The meta-text has therefore the function of orienting performative acts of aesthetic expression, dictating procedures for organizing information and/or generative processes. The directives of the meta-text, however, do not necessarily impose restrictions. The proposed creative strategies may suggest, orient or modify the creative fluxes, but they only partially determine the final content of an artwork, since performative processes are always subject to the contingency of actual situations. It is foreseeable that during the process of producing a text, of performing a meta-text, the praxis would act retroactively, causing the meta-text to be reelaborated. In this case, the feedback enriches the original meta-text that can absorb new procedural strategies, otherwise unimaginable. At the same time, the meta-text itself could be instituted as an autonomous text, with its own aesthetics, language and graphic style. The gradual insertion of this media language into our aesthetic universe may bring new visions to our concept of an artwork or text. The genesis of every work, as well as its further reverberations, may be seen as extensions of the work itself bringing new venues for theory, history, education and criticism.

IV. Communication Models

Departing from the Communication Schools, the models of communication are usually classified on linear models (Shannon and Weaver, Lasswell), circular models (De Fleur, Osgood and Schramm, Dance, Maleztke), and reticular models (Newcomb, Gerbner, Westley and McLean). The Linear Models treat communication as an unidirectional linear process between sender and receiver (who is passive). The Circular Models see communication as a potentially mediated relation between sender and receiver, introducing the possibility of mutual influence. The reticular models approach communication also as a result of psychological and social aspects that flow through complex webs/nets of relationship in order to generate opinions, attitudes and actions [3]. Further advances have proposed the semiotic model (Saussure, Peirce, Eco) and the socio-semiotic model. The semiotic model states the multidimensionality of the code, whereas the socio-semiotic model works with the multidimensionality of the agents' backgrounds (when the meaning of a 'code' may depend on one's evolving cultural record). [4].

The way authors categorize models vary in function of how they approach the studied phenomena, but mostly the issues are linked to the following attributes: if the contact between agents is direct or mediated (and how media can bias it); the degree in which the code is controllable and predictable (within agents and another environments); the immanent power embedded into the code (the impact it can have over people and the world); how free agents are before, during, and after communicating (being under linguistic coercion is different from peer submission); how free from (cultural, semiotic, sociological, economic, political) influences such process can be; its degree of interactivity and its openness to active and effective participation; how interaction between agents goes on (e.g. exchange, marketing, negotiation, game); the agents' intentions and aims behind the stage (e.g. to seek for understanding, to set an opinion, to change a behavior, to reach an agreement, to make a deal); how to integrate humans (individual, group, and mass levels) with technology (media, internet, robots) and Justice (social justice, economic justice, political justice); and so forth.

V. Artificial Communication

Before even trying to model communication, some computer scientists do need to grasp the phenomenon in itself. That means they start looking for what it is to communicate and where it comes from. In short, how to model and program both the origin and evolution of communication. For instance, [5] uses a mediated interaction game between human agents to understand how (sign) communication systems emerged, whereas [6] works rather with artificial embodied and situated agents that might develop interaction and communication through cooperation. Some authors are interested in the role of sensorimotor, cognitive, neural and social factors for "the emergence and establishment of communication" between artificial agents [7, p.2397]. Again the simulated agents are able "to build, through interaction, a functional representation of the environment and use it to communicate" [7, p.2398]. Others have been calling attention to the (social) robots that could spontaneously generate communication systems from the simple information exchange about "food location" – including deceptive communication between "unrelated robots" [8]. Finally, [9] has presented the complexity of the communication patterns originated from the experiment from [8]: with robots acting alone or as a group, and employing cooperation, exploitation, or deception strategies.

In the "synthetic ethology[2]" artificial creatures can only develop communication through their descendancy – showing how such capacity defines a higher (evolutionary) fitness, since "creatures must communicate in order to breed and carry on their genetic line" [10, p.68]. In the same direction, [11] dealt with simulated organisms referred to as the 'simorgs': there was a breeding cycle to every pair of randomly matched simorgs, and "the mutation rate was a 0.01 probability of one mutated allele per birth" [11, p.4]. After 50 breeding cycles the authors have found that simorgs associated with C+L- evolved the most structured communication conventions[3]. This work was based on [12], whose 5,000 breeding cycles experiment (for simorgs) has indicated that communication led to "fitness increases approximately 26 times faster" than the option, and that under "communication and learning the rate of fitness increase (was) nearly 100-fold" [12, p.161].

VI. Modeled Communication

Reference [13] introduces a robot capable of learning human communicative behavior, a robot seen as a "social being". In such experiment, the robot interacts with humans to acquire intentionality (the use of X to obtain Y) and can empathetically understand "the communicative intentions of other people's behavior" [13, p.47]. Here communication is the by-product of the dynamically (sustained across time) mutual behavioral convergence, which implies a robot programmed with a "value system" and a "learning mechanism". The machine needs to "understand other people's intentions" in order to react accordingly, and eventually to reinforce some actions in detriment of others. Then feedback, joint attention, empathy, and learning are the building block to produce a communicative behavior.

> Communication is the act of sending and receiving physical signals from which the receiver derives the sender's intention to manifest something in the environment (or in the memory) so as to change the receiver's behavioral disposition […]. Communication enables us to predict and control other people's behavior to some degree for efficient cooperation and competition with others. [13, p.48]

Reference [14] also presents a robot that can "learn to communicate with (human) users from scratch through verbal and behavioral interaction" [14, p.38]. This machine also has "beliefs" (a system to 'translate' and react to utterances), learning capabilities (that generate new beliefs to new experiences), and a sharing coordination (to align mutual utterances and actions). Again the acquisition of communication is done through interaction, feedback, and adjustment. For example, "LCore[4] enables the robot to understand […] utterances of users, respond to them with […] questions and/or actions, generate […] utterances, and answer questions" [14, p.39]. Robot goes dynamically linking the user's utterances (verbal and/or behavioral) with its owns, rearranging the beliefs accordingly to the (un)successes. The development of such mutual utterance negotiation and convergence is taken by communication – which is not modeled nor programmed directly, but arises as a system's by-product.

VII. Artificial Creativity

Reference [15] is mandatory when it comes to computer creativity. After defining the three forms of creativity (combinatorial, exploratory, and transformational), she mentions programs that can "design Palladian villas, Prairie houses […], baroque fugues, modern jazz, drawings of acrobats, story-plots, 3-D silicon chips, or chemical molecules" [15, p.74]. A particularly interesting approach is done by [16], who writes about the possibility of copyright for artificially intelligent authors and their creative production. [17] want creative machines that can invent (while pursuing scientific discoveries) and eventually persuade [17, p.7]. Reference [18] have presented examples of computer programs that rediscovered "a variety of concepts and conjectures in number theory" and "a number of numeric laws from the history of physics and chemistry", working also with "equation discovery". One of such programs was Bacon, "which rediscovered Kepler's third law (and) the ideal gas law" [19, p.37], as well as the Ohm's law, Snell's law, and Black's law [33]. As [20] points out, AI systems have helped to discover new knowledge in scientific fields such as, for example, reaction pathways in catalytic chemistry, quantitative laws of metallic behavior, quantitative conjectures in graph theory, and temporal laws of ecological behavior.

Reference [15] also registers the programs based on genetic algorithms (GA), which enables it to alter its own rules at random. As she says: the "solutions that result from the newly altered rules will be unpredictable", given that the "program's ability to perform its tasks gradually evolves" [15, p.75]. A program that can alter its own rules leads to think on self-programming machines. Reference [21] for instance approaches the "problem of programming without a programmer or performing complicated tasks without human will or intervention". Reference [22] aims at machines "able to adapt to unforeseen situations in open-ended environments", whose adaptation would "be performed automatically, i.e. with no further intervention by programmers after [the] machine enters service" [22, p.1]. Such ability is related to the property of an automation "to rebuild itself" [23, p.195] or the opposite. Reference [24] deals with "machines that act as

[2] The study of the (human or animal) *ethos*: character formation and evolution, and behavior.

[3] C+L- stands for Communication (*permitted*) and Learning (*not permitted*).

[4] The adopted machine communication learning method.

autonomous modular robots and are capable of physical self-reproduction" [24, p.163], whereas [25] seeks for the potential to build "POEtic machines" – a robot that can grow from the scratch [25, p.68-9]. The opposite of a machine that can (re)build itself is one which is "capable of self-destruction". Reference [26] studies the "artificial death" for robots, software, and systems. Moreover, they try to understand a machine able to suicide or self-sacrifice.

VIII. Artificial Artists

Aaron, the continuously designed and redesigned software created by Harold Cohen, could be seen as an e-author (see www.aaronshome.com). Since he was a young painter in England, Harold Cohen was concerned about representation and meaning, even though he was not a representational painter. In 1968, he was invited to come to the University of California at San Diego where he was introduced to the art of programming. There, he continued to investigate how marks acquire meaning, but now through a new medium. Provided with simple rules, the computer would draw endlessly. Aaron becomes the name of an electronically constructed author and Harold Cohen was acknowledged as the meta-artist. In spite of that, Cohen has been consistently rejecting any claim of machine creativity – because he suggests that "the human mind takes a different route to creativity, a route that privileges the relational, rather than the computational" [27].

> Margaret Boden […] distinguishes between two broad categories of computer art—interactive and standing alone. In *interactive* art, some or all of the creativity is attributed to the programer or the human participants. By contrast, the stand-alone types of programs can be credited with creativity: One is *generative art,* or G-art, in which performance may be a stand-alone matter, wherein the computer generates the result all by itself. "The pre-eminent case of G-art in the visual arts is AARON, whose programer tweaks no knobs while it is running. In music, perhaps the best- known example is the work of the composer David Cope" […]. Another type of "creative" programs is *evolutionary art*, in which the computer produces novel results by capitalizing on the evolutionary principle of random variation and selective retention. [27].

Reference [28, p.186] works with genetic algorithms in (visual and musical) artistic domains, such as the computer automatically generation of pictures, textures, 3D shapes, jazz solos, and so on. [29] cites the Simon Fraser University's Metacreation Project, in part dedicated to develop "artificially creative musical systems" such as Algorave (an event where people dance to music generated from algorithms), MuMe@ISEA (a concert of software autonomy in music), and Deus Ex Machina (creative software for musical metacreation) – and asks: "what if computers themselves become advanced enough to design the software that is used to create paintings, sculptures, symphonies or stories?". Reference [30] made reference to papers covering "artificial creativity" on visual arts, music, poetry, punning riddles, narratives, and cooking. For them, we "cannot expect the world's creative people alone to supply artefacts (such as a joke for a speech, a recipe for a party, or a painting for a present) for such a huge demand, so autonomously creative software will be necessary". For instance, [31] have developed "an artificial [creative] chef that produces novel salad recipes with limited human assistance" [31, p.38]. Finally, [32] bring an example of a creative robotic performance. To further examples, see [33].

IX. Artificial Writers

The meaning of the term 'meta-artist' could also be extended to include artists who design not only systems but electronically-defined 'authors', that is, computational systems or software that attain quasi-autonomy in making their design decisions, or that may even be designed to evolve in complexity as they learn through experience in their signal-processing endeavors. Some human agents, acting as meta-authors, have conceived and actualized virtual entities that could be seen as e-authors. They are the end product of a process of programming and design of computer systems that attain semi-autonomy in the structuring of complex signs. An interesting trait on such systems comes from the fact that a computer program is in itself an encoded string of symbols, meaning the following: a program is a 'text' that can generate another 'texts'. Such symbolic lexicon and syntax are in the very basis of what we call intelligent or creative machines and, contrary to what one may think, do not always specify all intermediate processes or even determine all the final results. In short, the artificial writers are not programed to deliver a predictable piece of text; they are rather programed to 'invent' in some extension. Anyway, either more autonomous or with human cooperation, here there are some examples of artificial writing.

Reference [34] discusses eight poetry generators, computer programs that either manipulate (human) user inputs, internet texts, or that generate autonomous content – sometimes in a participatory, instable, unpredictable way. Reference [35] studies a machine able to generate "short, dream-like narratives that are uncannily similar to those found in the corpus" – based on human transcripts. Reference [36] introduces a program that tells stories – intriguing, with a hint of mystery, and in a correct English. Reference [37] develops a "semantic reasoner" to improve the performance of the five tested automatic story generators – calling attention on how the entertainment industry uses it to generate automatic scripts and reports writing. Literary machines are analyzed both by [38] and by [39]. The former state: "writing is no longer merely a human activity (…), but also the outcome of a software system", and evoke a project "to build an Internet robot that could automatically generate books (…) and upload them as e-books to Amazon's Kindle Bookstore" [38, p.2,7]. The later traces the historical trajectory of the combinatorial machines, artificial poetry, computer text generation, and collaborative writing; and says: computers and networks are able to "generate an output that can neither be predicted nor kept under control by writers or by readers" [39, p.4]. Finally, [40] brings the automated journalism: "algorithmic processes that convert data into narrative news texts with limited to no human intervention". To more examples, see [41].

X. Conclusion

The artificial life will only make sense if it can sustainably communicate with mankind. Robots do need our approval in order to be labeled as intelligent and creative. Whenever their existence and behavior become disruptive to mankind, either as expressive or communicative devices, then they would be no longer welcome. In spite of any necessity or attractiveness attached to machines, our (material and symbolic) interaction with them must at last be sustainable. However, such coexistence sustainability point of equilibrium with the referred 'artificial social agents' remains, unfortunately, an unknown field in itself – still open to ethical debate.

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