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<MT>Algorithms and Interoperability between Drama and Artificial Intelligence

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<A>Introduction

<TEXT1>Throughout the history of digital performance there has been a continuous and important focus on the interaction among the performer's physical actions and the other elements of the performance such as objects, devices, and digital contents (Dixon 2007). The different ideas and approaches surrounding the mediatization of culture over the past 30 years have fostered a discourse that contributed to the ongoing innovation of performance conventions. Beginning in the 1980s, the video became a common element onstage, and the consequence was that theatre studies tackled a new configuration of the elements of theatre. Elinor Fuchs saw the use of the electronic image as focusing on the textualization of performance, in contrast to the idealization of presence during the 1960s (Fuchs 1985). More recently, the intricate weaving of digital media in the work of The Builders Association has led Bonnie Marranca to rethink the traditional story design as a hybrid between media and dramaturgy, and she coined the term "mediaturgy" (Marranca 2010; see also Jackson and Weems 2015).

<TEXT>As matter of fact, most of contemporary intermedial performances have had, at their core, the exploration of the mediatization of the corporeal body. Thus, much attention, both by practitioners and scholars, has been paid to the theoretical or practical challenges posed by the relation between the physical body of the performer and its transduction into other media. The topic has been addressed either as a poetics of doubles or as the denouement of our fragmented and dislocated presence in the contemporary world. The topic varied from virtual embodiment (Broadhurst and Machon 2011) to the intersections between the body and technology (Parker-Starbuck 2011), and has also been viewed in the light of a shift in audience cognition (Causey 2006).

Throughout the same decades during which we have seen the development of digital and multimedia performance, there has been other research that is also closely related to the digital revolution, but focuses less on the enactment of the body/presence dichotomy and leverages more the relation between interactive technologies and the design of the event. This includes research that applies a computational approach both to the design and the enactment of the dramaturgy of the event, regardless of the stage design or the actual multimedia systems used to deliver the performance. Furthermore, this work also includes all practical and theoretical research that seeks to

represent the notion of the dramatic event as an algorithmic-like process. Such a range of topics provides fertile terrain for the realization of the impact of the computational algorithms on theatre practice and theory.

<A>The Influence of Computation

<TEXT1>The notion of computation has played a role in contemporary performance beyond the notion of intermediality, especially for experimentation that approaches the performance as the product of an interaction design, hence as a specific type of coding involving the formal elements that shape the relation between the event and the users (Kolko 2011).

<TEXT>Clearly the boundaries are not fixed and, in some cases, it is difficult to differentiate between the intermediality of the performance and its computational structure, particularly when the artistic enterprise involves software research and innovation. Take for example the case of Marcel·li Antúnez Roca's *Afasia* (1998). The artist joined with the engineer Sergi Jordà to create soundbots (robots that work as remote-controlled musical instruments), a wearable control device (the so-called dresskeleton), and also the first version of software that controls all elements of the stage technology (video, sounds, lights, robots), which was further developed and named after a 2002 performance (*POL*) (Antúnez Roca 2014; Pizzo

2016b). The software aimed to provide the performer with full control over the entire web of technology onstage, turning the artist into a multimedia storyteller.

POL is an editor of stage events that uses commercial programs and MIDI protocols to link diverse types of sensors with the images, sounds, and robots. POL also incorporates the standard dramatic format, thus encoding the performance as a sequence of scenes corresponding to one specific setting of the interaction design. For each scene the artist can choose a specific mapping between a series of actions/events and a number of multimedia outputs. For example, in one scene the voice of the actor can trigger a video, while in another scene, the same voice may activate a camera. Here, the control allowed by the software plays a key role in the performer's empowerment:

Antúnez Roca was engaged in a continuous "fight" with a technological universe from which emerged a discourse about the overflow of information in the contemporary world of media. The continuous manipulation of content through the software alluded to the contemporary anxiety about being in control of the overwhelming flow of communication, so to bring people on the verge of aphasia, according to the artist.

POL belongs to a larger family of software intended to gain computational control over a performance, and is key in the history of the interrelation between performance and computer

science/engineering (Birringer 2007). This family can be divided into two macro categories: technologies for the capture and analysis of stimuli, of "events" and actions; and technologies aimed at creating hypermedia, audiovisual, or, more generally, multimedia "events."

The first category contains all the systems aimed at the capture and analysis of movement (motion tracking). This includes a long list of technologies available on the market that can record movement to be rendered (simultaneously or afterwards) as a character in a videogame or film (Pizzo 2016a). Generally, these solutions aren't designed for a live multimedia performance but are geared for the film industry's need for precision in mapping, for instance, facial expressions in motion capture. In live performance, for example, the speed and processing of data, or the analysis of expressive gestures and social signals, might be more important than the precision of the capture.

These peculiarities of live events such as theatre or dance pushed forward the development of performance-centered software that gained relevance outside the mainstream commercial market. For example, EyeCon software, developed by Frieder Weiss, was designed to facilitate interactive performances and installations in which the motion of human bodies is used to trigger or control various other media (Weiss 2008; Wechsler

2011). EyesWeb, developed by the InfoMus Lab at the Department of Computer Systems and Telematics of the University of Genoa since 1997, has libraries of resources (subroutines, classes, values, specifications) dedicated to the inclusion of the expressive and social elements of behavior (Camurri et al. 2004).

Although the motion capture systems are important computational tools for theatre, they do not constitute the only type of technology capable of detecting stage events; movement and space aren't the only dimensions of performance. The acoustic dimension of the performance—including sounds produced live by performers and objects as well as recorded sounds—contains meanings and indicates events and must therefore be analyzed and treated independently. For this purpose, some common software modules are available for the detection and analysis of the amplitude, the frequency, and the spectrum of sound. (Imagine, for example, a software that modulates the intensity of the stage lights based on the flow of the lines spoken by the performer.) These are possible applications implemented by numerous sound-processing software currently available (for example, Audacity, WavePad, or SonicVisualiser, among many others).

To the second macro category (creating multimedia "events") belong all the software dedicated to sound and video processing.

These are used to manage and consequently integrate technologies specifically conceived for sound, video, or to handle the data produced by some sensors within a single environment (the live event). The most famous of these programs is Max/MSP/Jitter, an application originally created by Miller Puckette at the IRCAM in Paris in the mid-1980s as a tool for computer music. Yet, there are numerous programs that were developed for the management of audio synthesis and used for live events: Pure Data (PD, an open source program developed by Miller Puckette himself in 1990); or Csound, a program exclusively dedicated to audio, developed by Barry Vercoe at the MIT Lab in 1984; and SuperCollider, a program that is both an environment and a programming language, originally created in 1996 by James McCartney for the real-time management of audio synthesis and algorithmic composition. The same can be said about programs dedicated to video processing. For example, LiVES, a free software developed by the artist VJ Gabriel Finch and released in 2009, combines professional-level, real-time video performance with nonlinear editing. Or vvvv, a graphical-textual hybrid programming environment, based on a modular architecture similar to Max and PD, which also incorporates the idea of continuous data flow, programmable even in real time. One of the performance-centered control applications is Isadora, a commercial software created by Mark Coniglio that provides a

graphical programming environment for interactive control over digital media. It is based on a very long list of functions (called "actors") that can be linked to process in real time a wide range of media content, as well as other data produced by sensors. This allows the artist to create an almost infinite number of combinations in order to design the scene according to his or her will. This software system was created by Coniglio based on his experience with the dance company Troika Ranch (Coniglio n.d.).

What is relevant here isn't the way these systems are used, but the fact that they rely on a sort of abstraction of an event (being it a sound, a video, or a physical action); that is, they provide some algorithmic representation of a fair part of all the elements that constitute the performance and allow the artist to use algorithmic structures to control the flow of the show. At the base of this functioning is the algorithmic representation of these elements (that we can abstract with the term "content") and of the controls. In other words, performance-centered control systems such as POL and Isadora rely on some computational formalization not only of the content (i.e., lighting hue represented as mathematical values), but also of more complex elements such as the narrative sequence. For example, both systems assume that the performance is a structured list of units, a cluster of actions. This means that

POL and Isadora have coded a computational model (however elementary) of the dramaturgy of the event.

With such types of software, we not only consider the skills of the artist in using the digital technologies within a theatre frame; we also appreciate the configuration of the event in terms of computational instruction as a whole. These programs also exemplify how computer science may contribute to the aesthetic of the performance.

<A>Rules and Contents

<TEXT1>The relation between drama and algorithms dates back to the very beginning of the computer age (Taylor 2014). Consider for example the famous ELIZA program created by Joseph Weizenbaum in 1966 at MIT; it is often counted as one of the first experiments of "artificial life," but at its core was the algorithmic formalization of dramatic elements. The starting point was the idea that the software was a tool for the author to create a dialogue. Weizenbaum wrote: "its name was chosen to emphasize that it may be incrementally improved by its users, since its language abilities may be continually improved by a 'teacher.'" Like the Eliza of *Pygmalion* fame, it can be made to appear even more civilized, the relation of appearance to reality, however, remaining in the domain of the playwright" (1966:36). Beside this paramount reference to playwriting, this

original (and only) implementation of ELIZA rendered, by means of computation, a specific framework for a conversation, a session between therapist and patient, modeled after the speech patterns of Carl Rogers. The system used different algorithms both to detect the input and to select the proper output from a database. "[T]he text is read and inspected for the presence of a *keyword*. If such a word is found, the sentence is transformed according to a *rule* associated with the keyword, if not a content-free remark or, under certain conditions, an earlier transformation is retrieved. The text so computed or retrieved is then printed out" (37). For that task, there were two main algorithms at work: a parsing one (for the keyword detection), and a combinatory one (for the phrase transformation). Moreover, these two algorithms, rather than modelling a synthetic agent, modelled a dramaturgical frame where the character performed by the computer featured specific behaviors that were believable only in that situation. The computer wasn't able to deploy a conversation on a wide range of topics; "the only serious ELIZA scripts which exist are some which cause ELIZA to respond roughly as would certain psychotherapists (Rogerians)" (42). This allowed the character to be believable even if the algorithm was conducting the conversation just by transforming the sentences of the user. The way the author has achieved the believability of the character suggests the second main implicit

reference to a dramatic device. In other words, the simplicity of the program coincided perfectly with the rigidity necessary for the role of a Rogerian analyst: the limits of the software matched the limits of the character to be represented. Just as any dramatic character is modeled according to the theatrical convention of the time, the Eliza character was defined by the specific computational capacity of those years.

Thus, in this first example of algorithmic performance, the intent was not to *create* a new artificial life but rather to *represent* a dialectic that simulates human interaction. ELIZA was conceived to represent a fictitious situation, to pretend to be what it was not; to provoke the illusion of reality. This dramaturgical device was, in turn, influenced by the Turing test—developed by Alan Turing in 1950 to determine whether a machine can exhibit intelligent behavior (by means of natural language conversation) well enough to convince the user that the computer “thinks” in a manner indistinguishable from a human. ELIZA leveraged the well-known therapist-patient relationship both as a way to simulate the aura of expert knowledge, thus putting the human in a subaltern position, and as a way to exploit the predictability of the clinical ritual to improve the computer system’s performance. Moreover, Weizenbaum’s research program was perfectly in line with the paradigm of behaviorism, which posited human intelligence in its manifestation at the

behavioral level, and with the nearly contemporary concern of social sciences for social rituals and scripts (see Goffman 1967), which transversally affected social sciences, psychology, and artificial intelligence until the formalization of the notions of *script* and *frame* by highly influential theorists such as Roger Shank, Robert Abelson, and Marvin Minsky (see Schank and Abelson 1977; Minsky 1997).

After the creation of ELIZA, the idea of a conversational agent, or chatbot, became a consistent and ongoing field of research, with a sort of revamp in the age of social media and endless online chats.

Another experiment from MIT exploited the human-machine interaction for a theatrical outcome. Claudio Pinhanez and Aaron Bobick presented *It/I: An Interactive Theatre Play* at the MIT Media Lab in 1997 (Pinhanez and Bobick [1998] 2002). In this performance, the artificial character didn't partake in a conversation, but was a sort of hidden entity reacting to the human character's actions by means of sounds, lights, and video projections onstage. The play was composed of four short scenes in which the computer presented the actor with several challenges. Here we can appraise a fundamental step forward in the dramatic agency of the algorithm. Rather than reacting to the user's stimuli, as with ELIZA, the autonomous agent has its own initiative and cues the human actor to react accordingly.

For instance, “*I* [the human] is sitting on the center of the stage, distracted by the music played offstage by a pianist. *It* [the computer] attracts *I*’s attention by displaying an image of the sun on the left stage screen. When *I* stands up, the image moves away, and a CG clock appears, running a countdown. *I* tries to hide from the imminent explosion, while *It* projects a movie showing that the clock can be stopped by a gesture” (Pinhanez and Bobick [1998] 2002:538-39). Clearly here there are a greater number of algorithms at play (computer vision, real-time rendering, etc.) but most relevant is the computational representation of the plot, i.e., the dramaturgy of the performance, as an *interval script*. Claudio Pinhanez conceived it as a

<EX>language for interaction based on the concept of time intervals and temporal relationships [...] An interval script associates a temporal interval to every action in the script. To each interval a label—past, now, or future—is assigned during runtime, corresponding to the situations where the action has occurred, is occurring, or has not yet occurred, characterizing what we call the PNF state of the action. This is a significant departure of traditional event reaction-based systems that cannot distinguish between events that already occurred (past) from the ones that are still to occur (future). (542)

<TEXT1>Alongside the script that dictates the sequence of actions to be performed in the play, clearly there was another script aimed at representing the single actions and allowing for some elementary form of computer reasoning. Just as the ELIZA transformation algorithm was able to handle words in order to represent meaningful phrases, the *actscript* directs the actions as a means of communication between the different modules of the system (for example, the *It* module tells to the CG module to render an animation) and between the system and the human character (544). These two scripts (the interval script and the *actscript*) are evidence of an important step in the relation between algorithm and drama.

ELIZA modelled the dialogic relation between a therapist and a patient as the ability (of the former) to recombine and re-use the verbal elements produced by the latter. The scripts in Pinhanez's systems aim to model the more complex notion of drama as deliberative actions performed by agents at the present time, in a logic-based sequence of events.

This step coincides with a shift toward the design of computer-driven agents that took place in the 1990s and incorporates previous seminal research on language processing and agents' theory (Schank 1975; Bratman 1987). For example, beginning in 1991, the work of the OZ Group at Carnegie Mellon University led by Joseph Bates charted author-centered research

in the field of interactive digital entertainment (Bates 1992); and the Synthetic Character Group at MIT Media Lab, directed by Bruce Blumberg, turned its attention to the world of classical animation for children, but according to the paradigm of interactivity. Both cases exhibit three fundamental components: the creation of a story-script to be enacted, some interaction rules between relatively simple characters, and a fascination for virtual reality as a place of entertainment. And at the base of these three components rest some traditionally theatrical elements: drama, character, and space.

<A>Intermediality and Interoperability

<TEXT1>The past three decades in the field of digital computation have seen an increasing interest in foundational elements of theatre and drama. According to Brenda Laurel's famous account, the very nature of the computer is somehow theatrical, meaning that our everyday interaction with digital devices can be recapitulated according to the notions of real time event and agency (Laurel 1993:105).

<TEXT>Yet, it is worthwhile to note how this cross-fertilization works the other way around too, that is: how much computation and algorithm may shed a new light on the way we elaborate the notion of theatre and drama.

Take for example the notion of the interoperability of data as it has been fostered by computers and the internet. For the field of theatre research, Miguel Varela has suggested to exploit that notion (within the frame of the Semantic Web project and the idea of annotating a piece of information (any content that can be interpreted as bearing a meaning, such as a text, an image, a sound in such a way as to be handled by algorithms), especially for its intrinsic potential to catch "the atmosphere of sophisticated disagreement that characterizes performance research" (2016:137). The Semantic Web project and the Linked Data¹ are the essential starting points for an algorithm that aims to incorporate different media content, and thus became of seminal importance in contemporary theatre where the performance has increasingly incorporated different media.

Yet the notion of interoperability may be linked also to the notion of intermediality in performance, an idea that emerged during the same timespan covered by the implementation of artificial agents within a dramaturgical frame (Bay-Cheng et al. 2010). Within this debate there is a shared opinion that theatre works as a "hypermedium that was always capable of incorporating, representing and on occasion even thematizing other media" (Balme 2004:17). The theatre is intended as "a physical hypermedium, whereas at the level of sign systems the Internet is a virtual hypermedium" (Kattenbelt 2008:23). Balme

reckons that beyond the "text oriented and technologically oriented media theories" there might "a third path to explore, which would necessitate examining particular features of theatrical mediality" (2004:17). Balme (and somehow Kattenbelt too) suggests that this third path will open to follow the trail of intermediality (the idea of theatre as a hypermedium) (Balme 2004:17). We suggest that this trail may be also be illuminated by the notion of interoperability in computation.

Kattenbelt also notes that "computers, in which words, images and sounds are made, processed and played back, are usually referred to as multimedia computers" (2008:22). The upsurge in advancements in digital computing matched the increased medialization of the theatre stage as much as the medialization of our everyday lives.

This hypermediality coincides with (and is the outcome of) the interoperability paradigm, where an endless series of connections and interactions among diverse and sparse data carrying any type of content (image, sound, text) may occur seemingly because of the way they have been annotated by means of metadata.

The rise of intermedial performance and the interoperability of media was enabled by the availability of digital computing, which simplified the control and management of multiple media onstage. If we think of the complex stage

management needed behind such works as Piscator's *Hoppla, We're Alive!* (1927), it is indisputable that nowadays the interaction between stagecraft, film, and audio would be seamlessly run by a computer.

In other words, interoperability is the basis of the multimediality of the computer, which, in turn, fostered the intermediality of performance, and so computation has become a commonplace asset in contemporary theatre productions.

In the terms set by Balme (2004:3-5) it would seem possible to recognize in the theatre theory of the 20th century a tension between a matrix defined as "essentialist" (the gaze directed towards the elements that make the theatre a specific and unique media) and a second that can be called "constructivist" (in which the live event is characteristically composed of multiple media). This second model indirectly proposes a nonspecific idea of theatre and performance. From this perspective, the study of theatrical performance would not constitute a verification or recognition of the relevance of an event with respect to an ontology of elements or to an aesthetics. In Balme's terms, theatre studies "in place of a perspective centred on the doctrine of media specificity, [...] must consider theories based on notions of intermediality" (2004:2).

But here we could be faced with a problem. How can we renounce the essentialism of the face-to-face communication

between performers and spectators while preserving a clear demarcation between theatre and literary criticism? In other words, if our gaze focuses on the web of media (both as codes and as cultural domains) we would somehow be induced to dim the preeminence of the face-to-face event (or the performance feedback loop [Fischer-Lichte 2008]), and then we may find ourselves back in the old field of dramatic criticism, accounting only for the text (either intended as dramatic literature or somehow revamped as multimedia score).

This conundrum follows an opposition between drama as domain of the author and performance as domain of the audience.

Schechner has stated that

<EX>the drama is the domain of the author, the composer, scenarist, shaman; the script is the domain of the teacher, guru, master; the theater is the domain of the performers; the performance is the domain of the audience [...] And just as drama may be thought of as a specialized kind of script, so theater can be considered a specialized kind of performance. ([1977] 2003:70)

<TEXT1>This opposition cannot be solved within the same theoretical framework that generated it. On the contrary, it is possible to try and see the whole issue from another perspective that considers the notion of the algorithm, starting from two simple observations.

First, the computation of algorithms in itself doesn't have a specific seat in the arena of media because it is by its own nature cross-medial. Better yet, we may say that the algorithm is media-neutral: it may be the instruction for the computer to enhance the colors in a picture as well as for a robot to bake a cake (we draw the analogy between algorithms and recipes from David Harel [2004]). Second, the algorithm is mainly a way to solve problems by performing a finite number of operations (sequences of instructions) on any element (such as a string of data), effectively acting on some input to yield some output. Therefore, on the one hand it belongs to the realm of the script (but it can be content-neutral), while on the other hand to the realm of performance (but is media-neutral).

The algorithm's core idea of managing content by means of executing actions can be represented as the relation between two types of instructions: content instructions and control instructions. The first type refers to the notion of content, i.e., the domain of the real world addressed by the algorithm. Let us assume, for example, that an algorithm implements the control of the stage lights and the method used consists in modulating the hue of the prevailing light depending on which character is the focus of the action at a given point. Also, the algorithm may decide the hue distance for two characters onstage, leveraging the common traits of the characters. Now

let's imagine a scene with Hamlet and Ophelia and see how such an algorithm might control the lights accordingly (i.e., controlling the content of the scene). Because we assume that Hamlet and Ophelia share some common traits of honesty and passion, let's say that Hamlet's hue is some form of orange, while Ophelia is some form of red (orange and red are similar colors in hue—warm colors). When some of the characters' traits diminishes in intensity, the color will appear less saturated. The audience will recognize the common traits of Hamlet and Ophelia with the commonality of colors belonging to the same hue type, and the intensity of these traits through saturation. These operations (or instructions) require some form of representation of the specific domain they are dealing with. Therefore, the algorithm may resort to the color space HSB (Hue Saturation Brightness), where the hue value is represented through an angle (from 0 to 359.99, from red to orange, yellow, green, blue, purple, and red again). In this representation, the angular distance is the range in hue between two colors, and the saturation is on a scale from 0% to 100%. The algorithm we have imagined here may assign colors to characters by computing the number of their common traits and therefore the contiguity of their colors (for example, diminishing the intensity of a character is translated as diminishing the saturation value). This is a typical example of content instructions: i.e.,

instructions that decide how the content is dealt with within the algorithm.

Complementary to the above, the control instructions determine the flow of the execution of the algorithm. They control the decision of what instruction is to be executed next. It is important to note that these instructions are independent of any content; they abstract from the domain on which they operate. An instruction algorithm may sort sizes regardless of the domain to which that size refers (weight, distance, etc.), while the content instruction we have described will work only on that domain representation (color HSB).

Although there are many kinds of control instructions (also called control structures), they can be reduced to three: (1) an assignment operation that sets a variable to a value (i.e., changes the content of given memory cells); (2) a conditional operation (an if-then-else statement is a simple control that tests whether a condition is true or false and acts accordingly); and (3) an iteration operation that performs recursive instructions to satisfy a certain parameter (i.e., a control that iterates an action for a given amount of time or while a given condition holds). These are the instructions that allow the algorithm to operate the changes to the memory, and so move from input to output.

Clearly the two types of instruction are deeply interdependent. So, for example, if the honesty trait for Ophelia diminishes in intensity, then the saturation diminishes as a consequence: if-then being the control structure, and saturation being the content instruction.

Bearing in mind this paramount distinction illuminates the dichotomy in literature on performance intermediality: performance studies has always accounted for the live event while media studies has focused on the content. This dichotomy can now be viewed in the light of algorithms.

Content instructions are applicable to media studies because they refer to the content (both in term of codes used by the media and cultural constructs); they represent what the content "is" (the so-called data type) and how it is organized (the so-called data structure), and therefore prescribe the kind of things that may be done with it. Often these prescriptions are considered implicit, and common sense says that the numbers can be added together , sounds can be heard, and images may be seen, but in a formal system they need to be explicitly stated. Therefore, the operations allowed on a content depend on how that content is described. The content instructions contribute to the annotation of metadata and, vice versa, the creation of metadata requires a representation of the content.

Control instructions relate more to a performance studies perspective not because they focus on face-to-face communication but because they are centered on the event. A control instruction is about what happens next: What is the order of events that happen? What is the exact duration of each event? In such control structures conditional operations forbid the execution of something until some condition is satisfied; iterations regulate continuous repetitions for a set number of times or for as long as some condition holds. Note that relating the control structure to the performance doesn't mean to force the latter back in the realm of the script and drama. And this is because the control algorithm is content neutral. Even when the notion of drama has been seen under a proto-structuralist light (Politi 1924), or through the precise lens of semiotic approach (Elam 1980), the analysis formulated has been always content based. The relation between performance and control algorithm holds because the latter is not concerned with the narrative elements or values delivered by the drama or the script. Indeed, if we refer once more to Schechner's terms, drama and script are eminently content based; both are a form of content to be carried and transmitted even if by "just a messenger" (for drama) or by a "transmitter" (for the script) (Schechner [1977] 2003:71). Control algorithms are nearer both

to theatre as "enactment, concrete and immediate" and to performance as a "constellation of events" (71).

From this point of view, we can deduce that while media studies is more connected with the interpretation and representation of content in some format, performance studies is more connected with control. Thus, we can read a performance in terms of what content is handled (what the performing agents and objects "are") and what controls are at play (what the performing agents and objects "do").

From this point of view, a video onstage may be of the same narrative nature as a character: i.e., both represent a specific advancement in the plot; just as sounds or movements may be emotional states. A play may show the same control structure of a dance performance because both implement the same action-reaction logic even if the content represented is very different (the first might be based on the codification of psychological traits, the second on spatial dynamics).

As we see, this approach doesn't deal with the technology involved, neither does it confront the specific configuration of media or the dramatic narrative. Take for example *Before I Sleep* (2010) by the company dreamthinkspeak (Lavender 2016:65-76): this event shows its cultural affinity with the world of gaming entertainment not so much for any technological intervention but rather for its control structure (what the performing factors-

actors and spectators—do in the enactment). And, on the contrary, in terms of content, it is much closer to the play it originates from (*The Cherry Orchard*). Under the same logic, in terms of control and content structures, the recent hypertechnological 2017 production of *The Tempest* by the Royal Shakespeare Company may not reveal any difference from a more traditional staging.

Rather than proposing a novel approach to performance analysis, this schema evidences how the algorithm has been applied in order to implement dramatic features. Therefore, the relation between drama and algorithms in terms of rules and content may be further exemplified with both canonical examples and projects we have developed.

<A>Dramatic Control-Driven Algorithms

<TEXT1>In general, we can group under the umbrella of control-driven algorithms those experiments that employ either expressive Artificial Intelligence (Mateas 2001; Mateas 2002:186–200) or pervasive gaming (Sharp 2015:82–90). But, more generally, this represents a line of research and practice that falls under the wide rubric “interactive storytelling.” This term encompasses a diverse and sparse type of approaches where the main common element is the participation of some form of

computation in the creation or delivery of a narrative, regardless the media used for the presentation.

<TEXT>While in the experiments of digital intermedial performance the most important outcome is usually the live artwork produced, for interactive storytelling it is almost the opposite, and the attention is devoted to the software implementation of narrative or performative models. There are a number of projects that have distilled a set of designing elements that rule the event to be experienced. For example, Nicolas Szilas has established an interactive drama project (IDtension) where the notion of dramatic conflict has been modeled and implemented in a computer game called *Nothing for Dinner* (Szilas 2003; Habonneau et al. 2012). Another example is the result of two EU projects, VICTEC and eCIRCUS, that produced an interactive drama/video game that teaches children strategies to prevent bullying and social exclusion (*FearNot!*) and uses innovative psychology geared toward character building (Aylett et al. 2007; Vannini et al. 2011). These projects implement a computational model of dramatic elements as a therapeutic tool for the user, and are among a wide range of intelligent digital solutions for education and training. Yet the history of drama and algorithms also includes projects that model a dramatic frame purely for the sake of emotional engagement. The most effective example of a rule-based dramatic algorithm is the

project *Façade* (Mateas and Stern 2007). It is an interactive drama game experience where the player can interact with two autonomous characters in a graphic animation. The setting is the apartment of a young couple (Grace and Trip) who have invited a friend (the player) for a drink: throughout the evening the couple argues about their marriage and the guest is somehow forced to participate, take sides, and influence the couple's relationship by means of language and physical behavior. It is a sort of *kammerspiel*, a one-act play with two artificial characters and one human. Besides the coding effort behind the project, it is relevant here that the authors have devised an algorithm that controls the course of the action so as to shape a traditional dramatic arc. In other word, there is a so-called "drama manager" that controls the artificial agents' behavior in order to reach an emotional climax at a given point of the approximately 25-minute run and secure an appropriate ending. The algorithm works as a sort of hidden director who provides real-time instructions to the actors in order to guide their dramatic improvisation along a given score. To perform its task, the drama manager relies on a specific model of drama (it vaguely resembles the structure of an Arthur Miller-style modern drama) that has been encoded in terms of rules to be followed. The basic one is the sequencing of the scenes so that the

incidents enacted generally progress toward a higher level of tension than the previous ones.

This control algorithm (the drama manager) works regardless of the specific technological means used for an actual *Façade* run. It is independent of the media (the actual setting, the computer screen) and might be run to produce a list of voice commands or a written script that may be performed by live actors onstage.

Following this idea, at CIRMA (Interdepartmental Centre for the Research on Multimedia and Audiovideo; www.cirma.unito.it) we have developed a software system called *DoPPioGioco* (Damiano, Lombardo, and Pizzo 2017). It is a computational platform that intervenes in the performer-audience relationship as an “intelligent prompt” that suggests to the performer the next story chunk, taking into account both the audience’s emotional response and the performer’s decisions. The system is based on a multilinear narrative, rendered as a story-graph made of story units; after the performer has delivered the first unit, the system detects (by means of a camera) the audience’s emotional reaction and allows (by means of a tablet) the performer to choose whether to accommodate or to oppose that reaction (and to select the level of intensity). Once the performer has made a choice, the system generates the next suitable story unit to be delivered, and so on through the end unit.²

From the theatre studies point of view, the design of *DoPPioGioco* system acknowledges the relevance that storytelling performance has acquired on the contemporary stage (Borowski and Sugiera 2010), and relies on the centrality of the communal experience between the actors and the audience (Brook 1989). From the computer science point of view, the design of *DoPPioGioco* has two main sources. On the one hand it belongs to the field of Human Computer Interaction (HCI) but it looks at how media designs the audience's experience (Brooker and Jermyn 2003). On the other hand, it refers to the paradigm of improvisational theatre, and its influence on computational storytelling (Swartjes and Theune 2009; Perlin and Goldberg 1996). The dynamics of improvisational theatre has been described from the perspective of interactive storytelling, using the "decision cycle" from Alan Newell's *Unified Theory of Cognition* (1990; receive new inputs, elaborate new knowledge, propose actions to take, select one of those actions, execute the action) as a conceptual framework for analyzing the way each performer takes advantage of the scene-advancing moves of the others (Baumer and Magerko 2009).

At the core *DoPPioGioco's* model of interactivity lays an emotional system that is employed for tagging the story components, and a real-time engine that prompts the story units to be delivered.

DoPPioGioco works in a triangulation between three proactive elements: performer, system, and audience. Indeed, the performer isn't just meant to press buttons but is still very much in charge of the event. That is, the performer is not just selecting the next clip to play (i.e., managing the local agency in the interactive storytelling), but also managing the overall narrative (on the notion of agency see Murray [1998]). For example, if the performer selects more often a high intensity emotional attitude for the next unit, it is more likely that the story will reach an end unit faster than if the selection hits more often the low intensity emotions.

Projects like *Façade* and *DoPPioGioco* indeed belong to the domain of interactive storytelling and share common traits with the research on multilinear narrative. Yet, they aren't concerned only with autonomous editing of audiovisual content (see for example Manovich and Kratky 2005). Rather than proposing an automatic editing of clips, *Façade* and *DoPPioGioco* address the basic elements of the live theatrical event by exploiting the power of the control instructions. *Façade* used computation to provide an intelligent digital scenario for the player to interact with by means of the virtual world in a computer screen; *DoPPioGioco* envisions a system in which the setting is still traditionally theatrical and the role of the actor/storyteller and that of the audience/listener are still

very much separated, yet adds another level of interactivity by means of computation.

DoPPioGioco, like *Façade* is media-independent. That is, the control structure is effective regardless of the content. Even if the actual system has been tested in a realistic fiction-based narrative in which the performer acts as a traditional storyteller, the idea behind *DoPPioGioco* may be applied even to events less dependent on character and narrative. For example, the audience at a dance performance is invited to react with some emotional expression (clapping, shouting, jumping, etc.) to the dancer's movements. Then, the system communicates the emotion detected (via audio or video) to the dancer; the dancer then chooses the response and the system, accordingly, plays an appropriate music clip.

<A>Dramatic Content-Driven Algorithms

<TEXT1>Projects like *Façade* and *DoPPioGioco* work with the belief that the performance can be augmented by means of computational intervention in the dramaturgical design. Yet, as we have seen, for an algorithm to handle autonomously a specific element, the first step is to have a computational model of that element. Therefore, if the algorithm has to participate in a live storytelling, the designers of the system first need some kind of formal representation of the narrative elements.

<TEXT>For example, *DoPPioGioco* describes the multilinear story in the form of a graph (Aarseth 1997), encodes the emotional response of the audience using a cognitive empirical classification (GEMEP) (Bänziger and Scherer 2012), and models the performance in the form of a feedback loop between performer and audience (Fischer-Lichte 2008).

Clearly there are some content algorithms at work here. In *Façade* each scene is described by the designer of the system both in terms of the agents' behavior and values for the emotional tension. At the core of *DoPPioGioco* there is a system for tagging the narrative units (the tags mark the narrative unit either as start, or previous, or ending), hence a graph that represents both the suitable story advancement and the emotions that each unit is likely to elicit in the audience.

The notion of metatag is foundational to the semantic web paradigm and may be easily summarized as the most advanced way annotate content in such a way that it can be handled by the software. For example, according the paradigm, a media (such as an image) must be described in terms of date, size, colors,... in order to be handled by a ordering algorithm. Content's description, and the subsequent interpretation, has been the main concern in theatre studies; in particular research on intermediality often has to make sense out of the way live and media content is entangled within the performance (Salter 2010).

The notions of intermediality and interoperability may also go beyond the specific organization of the relations among content and be considered in the light of the standards used to describe the content. For example, *Alladeen* (2003), a collaboration between The Builders Association and the former London-based company Motiroti presented onstage screens showing videos of workers at call centers in Bangalore, India; live feed of the actors onstage, and a variety of other images. Some video in the show may be considered as a tool of verbatim theatre; some scholars read the onscreen images it as performers' doubles (Tonucci 2012); others have interpreted the intricate network of screened images as representing the alienation of the individual and commodification of cultural heritage (Durham 2009). Yet the interoperability paradigm may focus attention on which sort of content is handled, and how each element of the content is represented. In *Alladeen* there are characters represented as psychological entities; there are spaces represented as geographical and cultural locations; there is a story represented as a logical sequence of incidents.

If we focus again on the field of drama from the perspective of content-driven algorithm, the main contribution comes from the research on annotation in story and narrative. In the last decade, the emerging technologies for media indexing and retrieval, mainly geared toward multimedia content, have

addressed the markup of narrative texts, thus prompting a number of initiatives that utilize structured semantic representations. In particular, the pioneering work of Gian Piero Zarri at the French CNRS has produced the Narrative Knowledge Representation Language (NKRL) project that combines the use of markup for the encoding of the narrative content of text with the use of frames to represent the narrated story incidents (Zarri 1997). As part of the more general trend of constructing resources for the automation of language processing, David K. Elson at Columbia University introduced a template-based language for describing the content of narrative texts, with the goal of creating a corpus of annotated stories, called DramaBank (Elson 2012). It must be noted that these projects tend to focus on the expressive characteristics of the text, so the schemata they put forth can be only partially extended to other media. Moreover, relying on narratology, they don't elaborate a specific model for dramatic qualities.

Narrative annotation has extended to nontextual media (such as video and audio). A media-independent formal encoding of story structures for multimedia contents is provided by the OntoMedia ontology, utilized in the Contextus Project (Jewell et al. 2005; Lawrence 2011) to annotate the narrative content of media objects ranging from written literature to comics and TV fiction. In this case, the project encompasses some concepts

that are relevant for the description of drama, such as, for example, the notion of character. Mainly targeted at the comparison of story events and timelines across media, it lacks the capability of representing some core notions of drama, for example, conflict.

All these initiatives, though relevant at the theoretical and methodological level, can be said to lack the capability to represent the dramatic qualities of drama manifestations through media.

Over the past 10 years, based on the principles that inspired these projects, at CIRMA we have been working on Drammar, a formal representation of the core elements of drama (such as agent, unit, conflicts, etc.), and we have encoded it in a computational ontology in OWL (Damiano et al. 2019.³ In short, the ontology is based on the Semantic Web project (and its paradigm to connect pieces of information and knowledge, i.e. the Linked Data) to represent the domain specific knowledge about the elements of drama. This ontology has been tested against a well-established model for analyzing drama (Albert et al. 2016), and used for different tasks such as the preservation of drama as part of the intangible cultural heritage (Lombardo and Pizzo 2016) and the visualization of dramatic structure (Lombardo and Pizzo 2014). Drammar ontology also implements a model of descriptions of emotions and has been tested to verify

the mode in which the dramatic characters' (called agents in the ontology) interaction may elicit emotions (Lombardo et al. 2015).

The idea behind this project is that the elements of drama have spread exponentially in contemporary culture, and most of the content produced belongs to the area of "dramatic media" (Esslin 1988), i.e., media that display characters performing live actions, such as theatre, cinema, and videogames. The enormous amount of dramatic media objects shared by users of social networks generate the need for indexing and search tools especially geared to dramatic content. In addition, as we have seen, new forms of drama have used a number of AI techniques, through the use of machine-readable algorithms. Such scenarios advocate a carefully designed and theoretically sound model of drama, valid across different genres and media types. Drammar proposes a content-driven algorithmic approach for the description of dramatic events and supports specific components to augment the representation encoded in the ontology with further information obtained through automatic reasoning.

A formal computable representation of the elements that define an event as drama, as we have seen, is the first requirement for the use of a control algorithm for that event. The more precise and specific the content description, the better the rules will control the event. This holds for a

theatrical event that relies on computer-driven drama as well as for a videogame geared to the dramatic engagement of the player.

In the light of performance intermediality, the approach based on content algorithms might support the work of commentators to posit how media are distributed within the performance and how media function in the event. The analysis of contemporary theatre has devoted much attention to describing how the different media are deployed in the performance (i.e., the way the different media are organized and staged). An approach that focuses on the formal description of content (i.e., the type of data that define, for example, the qualities of being an agent in the narrative) may reveal the similarities between content manifested in different media. For example, in *Alladeen* the videos are staged mainly on a long screen that runs across the entire front stage behind the actors (in the first part of the show) and above the actors (in the second part). The numerous videos are organized as a kind of kaleidoscopic mix of graphics, documentaries, and live feed. Yet from the content point of view, the videos may be further classified. The image of the Virgin Megastore in the first scene, for instance, may be classified as a location (with all the qualities that define a location as such), and therefore commonalities might be drawn with others location content (the call center office, for instance). Or, keeping with this approach, and taking into

account - for example - the content that can be described as agent in the narrative, the focus might lean toward the commonalities in terms of content between the performer onstage and the video on the screen, or the sound of a voice in the speakers.

Drammar's formal representation of dramatic elements has been used to analyze the distribution and interplay of these elements between textual dramaturgy and musical dramaturgy in opera (we are currently working on an excerpt from Mozart's *Le Nozze di Figaro*). From the production point of view these same elements can be implemented in some control algorithm (as we have done for *DoPPioGioco*) to produce a computer-assisted performance where the computer functions as an agent in the event. Drammar is the first of its kind, and the field is still to be fully developed, although many projects are appearing with the goal of providing more elaborate and media-independent content representations to foster interoperability of information in the big data era.

<A>Challenges

<TEXT1>While algorithms are shaping our everyday life through endless applications within our devices and gadgets, they have also made their way into the theatre. Although it is possible to trace the role of computation in terms of technological

enhancement of the stage, there is still room to further explore how the theories that are at the base of computation and the principles that foster computer science can be applied to and utilized by contemporary performance. Bearing in mind the actual technological and scientific advancement it may be possible to pair the history of computation with that of performance and, eventually, find fresh and stimulating pairings to cultivate experimentation in both arenas. Behind this enterprise lies the need for hands-on interdisciplinary research that develops collaborations between both fields as well as ways to put theories into practice. The epistemological challenge is one of the most interesting of our age and we anticipate further collaboration between science and the humanities.

1. See https://en.wikipedia.org/wiki/Linked_data

2. Since this article was written, we further tested the system.

A short video demonstration is available at

http://www.cirma.unito.it/portfolio_page/doppiogioco/.

3. OWL (Ontology Web Language) is a language for the semantic web, and is used for authoring taxonomies and classification networks (<https://www.w3.org/TR/owl2-overview>). A comprehensive description of the Drammar project can be found at http://www.cirma.unito.it/portfolio_page/drammar.

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