The Humor Continuum: From Text to Smart Environments (Keynote Paper)

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***Abstract*—Humor is important in our daily life, whether our activities are at home, at work, or in public spaces, for example during sports or other recreational and entertainment activities. Until now, computational humor, the research area that investigates rules and algorithms to understand and to generate humor, has only looked at verbal humor and in particular puns (word play) and jokes. However, nowadays, humor has to be understood when it appears in digital audiovisual media, or in interactive virtual environments (game environments), or with the help of smart and interactive objects and devices, including wearables. In this paper we discuss the characteristics of the various media and environments in which humor can emerge. The goal however, is to make clear that future smart environments can facilitate humorous event creation by its human partners and can take the initiative to generate humor.**

Keywords – computational humor; game environments; smart environments; virtual agents; social robots

I. INTRODUCTION

The environments we live in are becoming smart. We use mobiles, tablets, laptops and PCs. We log in to social and professional media. We use ATMs and we pay electronically for our purchases, including books, music, travels. Public transport systems keep track of where and when we travel. We provide the cloud with personal information, pictures, videos, and opinions, but also with interests that shows from our search and exploration behavior. What we order, what we pay for, what financial or public services we use, it is registered. Smart environments add an additional and maybe an even more influential dimension to collecting (real-time) information about how we spend our life, our daily activities, our thoughts, and our relationships with others. Smart environments have sensors embedded in the environment (walls, furniture, devices, pets …) that monitor what is going on, but there are also sensors that are 'embedded' in the inhabitants and visitors of these environments. That is, in addition to sensors embedded in environment and its natural devices, there are sensors that have become part of our body and clothes, electronic devices that we take with us or that have become part of our clothes, our skin (electronic tattoos), under our skin or in our body or brains (implants). In this way not only how we behave, but also information about how we experience our activities becomes available and becomes integrated with other information available from environmental and body and brain sensors. We become 'things' that are part of the Internet of Things. We can think of typical human properties and how they will change or can survive in a world that has taken the form of an Internet of Things. First of all, we should mention that we are not necessarily passive inhabitants of this Internet of Things. We can and will be monitored, but clearly, all the information that is taken from us can as well be used to increase our well-being and make our life more pleasant and comfortable. That is, actuators in our home environments, in public spaces and in urban environments can use the information obtained from multisensory and long-term monitoring of our behavior to predict and anticipate our behavior and adapt the environment using its actuators to our preferences and capabilities. And, obviously, we can retrieve information we need from the smart environment and we can control the smart environment, by making clear our preferences and issuing commands. Obviously, the assumption here is that we own the smart environment, and this will not always be the case, neither in our home situation nor in work or public space situations. There will be other actors, including commercially and politically interested parties that will limit our freedom to cooperate with smart environments.

Obviously, this is only one part of the story. The second part is concerned with the way we organize our life, our activities and how we experience our contacts and relationships. Clearly, they are not yet fully predictable from smart sensors that are embedded in our environments and wearables. We cooperate with our smart environments, sometimes the environment is in control, sometimes we are in control, for example by issuing requests or commands to devices we own (but are integrated in the above mentioned Network of Things) or that are embedded in public spaces. Hence, on our request or command, our domestic, recreational or professional activities are supported by the intelligence that has been modelled and collected in these smart environments. Both expectations and support are mainly based on rational decision making. Almost twenty years ago, Rosalind Picard [1] introduced the notion of affective computing and therefore introduced a new research area. Based on earlier research from psychology she drew attention to the role of affect in interactions, in experience and in decision making. Our decisions are colored by emotional feelings and when interacting with computational devices, these affective feelings need to be taken into account. That is, these devices need to be designed, not only from a traditional visual or tactile viewpoint, but also from an interaction viewpoint that includes detecting

and interpreting of affective cues in the interaction and also includes, based on an affect interpretation, the generation of affective feedback.

When we have clear goals and have to operate in environments that expect goal-driven behavior we can expect behavior that aims at the choosing and processing of tasks that bring us closer to our goals in the most efficient way. This is especially the case for routine tasks, whether they have to be performed in public spaces, office environments or domestic situations. That is, affect hardly plays a role in our daily routine tasks and superficial interactions. It plays a more important role when we enter new situations, having to deal with unexpected events, engaging in interactions with new conversational partners, or 'just' enter a situation where our thoughts make associations with previous events, situations, and feelings. Amusement and enjoyment are positive feelings. We can smile or laugh about funny remarks – taking into account the context of the conversation, including the conversation so far - and we can smile and laugh about events that take place in our environment and the activities we are involved with. Rather than focusing on extreme and negative emotions it can be worthwhile to focus on how we can add humor to our environments - using digital technology - that helps to increase our enjoyment and, more generally, our well-being.

Humor has mainly been studied in psychology and in linguistics. From a computational view point, humor has been studied in Computational Linguistics (CL), Artificial Intelligence (AI) and Human-Computer Interaction (HCI). In the latter case, starting in the nineteens of the previous century the focus was on the role that humor can play in making interaction with a computational device more enjoyable and, because of that, maybe more effective. AI offered general methods for knowledge representation, reasoning and machine learning; CL added more detailed language-specific formalizations of these methods to the research field, HCI looked at the possible role of humor in interaction and how it can be embedded in the interaction with an embodied agent (virtual human) or social robot.

Humor is important in our daily life, whether our activities are at home, at work, or in public spaces, for example during sports or other recreational and entertainment activities. Until now, computational humor, the research area that investigates rules and algorithms to understand and to generate humor, has only looked at verbal humor and in particular puns (word play) and jokes. However, nowadays, humor has to be understood when it appears in digital audiovisual media, or in interactive virtual environments (game environments), or with the help of smart and interactive objects and devices, including wearables. In the last decade we have been offered digital technology that makes us an active node in the Internet of Things, meaning, someone that is not only monitored by the smart environment he or she inhabits, but also someone that has, if the environment allows, partly control of sensors and actuators that guard the environment. That is, the user, inhabitant or visitor of such a smart environment can make use of this environment to create humorous situations. When the environment is smart and its devices are smart, does it also mean that the environment can play a role in the humor that will emerge. Can it facilitate certain ways of humor making or can it take the initiative for creating a humorous situation or for delivering a (physical) 'punch line'? How can humor be displayed using this new technology and how can humor creation benefit from this new technology, maybe even allowing the creation of new kinds of humor?

In this paper we discuss the characteristics of the various media and environments in which humor can emerge. The goal however, is to make clear that future smart environments with its smartness integrated in tangible objects, wearables (mobile devices, including technology on or in our skin, our clothes and textiles, and wearables such as wrist, ear or eye devices) and public displays, can offer its human inhabitants the facilitation of humorous event creation and even can take the initiative to create humorous situations and events. Our focus is on incongruities, whether in language use, in interactions, in staged (intentional) humor in movies, comedy and real life, or in visual appearance or function of devices. Incongruities can be designed and manipulated, incongruity theory is the main humor theory in humor research and there are attempts to formalize it and examples of computational implementations are available.

The structure of this paper is as follows. In the next section (section II) we have some observations on humor theories. They usually focus on jokes. Despite this focus, we can learn some humor principles from their dealing with jokes. In particular we hope to learn about the ways humor can be dealt with in other than a verbal context. Section III introduces some issues that have to be dealt with in other than verbal contexts, among other things, multimodality and interaction, and accidental humor. State-of-the art research on nonverbal aspects of humorous interactions with virtual agents and social robots will also be discussed in this section. Section IV is about humor in real life. But we include observations on real life situations in comedy and movies. Section V summarizes our observations and we end with some conclusions in section VI.

II. INTRODUCING INCONGRUITY HUMOR

There is no comprehensive theory about humor, let alone a computational theory of humor that provides us with algorithms to understand and generate humor. Humor can appear and can be created in text, in speech and conversations, in cartoons, on stage, in movies, on television and in real-life events. And, of course, in situations that explicitly make use of digital media, including social media that mediate humor and including the technology of digital media that provides new means of experiencing and creating humor. We cannot expect to be able to formalize the understanding or creation of humor before being able to formalize the understanding of human behavior in general and the activities in which humans are involved.

This does not mean that useful things can't be said about humor. Many philosophers, from Aristotle to Henri Bergson, have investigated humor, and these investigations were continued by researchers from psychology, linguistics, and artificial intelligence. Observations on humor usually converge to three viewpoints, a cognitive viewpoint, a superiority view point, and a relief viewpoint [2]. The

incongruity theory represents this cognitive viewpoint. It deals with issues such as surprise, violating expectations, ambiguity, assessing new information, and interpreting and re-interpreting a particular situation or event. The other viewpoints can play a role when experiencing humor. We may feel relief of tension or feel superior to the 'victim' of a joke. It would not have happened to us, we wouldn't have act so stupid.

The humor incongruity theory has been developed for jokes. As mentioned, our concern is not the understanding of wordplay or verbal jokes and neither is it the emotional or functional viewpoints of humor. We want to investigate how in future smart environments humor can emerge or created, whether it is by its human inhabitants, making use of the smartness to create humorous situations or interactions or by the environment itself. A smart environment, with its sensors and actuators, allows the creation of humorous incongruities for and by its human inhabitants. For that reason, from the available humor theories, we will focus on this incongruity theory and what makes incongruities humorous. Not all incongruities are humorous.

Usually jokes have a structure where in the first part of the joke the reader or listener is presented with a stereotypical situation that evokes certain expectations about what will happen next. Then, surprise, something else and unexpected is happening (often the punch line of a joke) and the reader or listener realizes that a different interpretation should have been given to the supposedly stereotypical situation. This re-interpretation is the resolution of the incongruity, and for that reason the theory has also been given the name incongruity resolution theory. The question what makes an incongruity humorous is the main question that is attacked by incongruity humor researchers [2]. In computational linguistics and artificial intelligence research scripts, frames and other formalisms have been introduced to represent properties of objects, situations and events. These formalisms also allow reasoning about what they represent.

The concept of scripts and frames came from psychology, but AI researchers such as Schank and Minsky were looking for a computational implementation and therefore came with formal descriptions of scripts and frames. Understanding a particular situation means assuming that a particular frame or script describes this situation and therefore can be 'followed' to satisfy our expectations. However, the punchline or second part of the joke requires us to re-interpret the information given to us and conclude that not only we took the wrong view, but also that we understand how this misinterpretation could have happened to us. This requires some cognitive effort. This viewpoint, focused on rational understanding and reasoning about the world and therefore also understanding when that understanding and reasoning is violated, has received most attention in humor research.

In order to experience this 'cognitive' humor we need to understand overlapping scripts, that is, we need to be able to recognize our wrongness of understanding a situation and replacing it with a new situation that fits our understanding. However, rather than causing amusement, this change of perspective may lead to confusion. What are the conditions that lead to a humorous experience? Research into this incongruity resolution theory has been conducted with the aim of finding such conditions. There are overlapping scripts that describe a particular situation, we are fooled in following one script, and then realize we should have followed a different script. What are the properties of these different scripts that lead to humor, rather than 'just' surprise and maybe confusion? Can we find conditions that guarantee humor? Victor Raskin [3] introduced the Script-Based Semantic Theory of Humor (SSTH) in 1985. It was followed by refinements and extensions leading to more advanced theories such as the Ontological Semantic Theory of Humor (OSTH) [2]. But the main elements remain, that is, in order for a text to be a joke it has to be compatible with two scripts and in order to be humorous the scripts must be in a certain type of opposition. Typical script oppositions are, for example, real vs unreal, possible vs impossible, sex vs no-sex, life vs death, and so on.

A standard joke to illustrate this theory is the following:

"Is the doctor at home?" the patient asked in his bronchial whisper. "No," the doctor's young and pretty wife whispered in reply. "Come right in."

Maybe it is a rather artificial joke, but it illustrates overlapping and opposing scripts in a clear way. We have the visit-doctor script and the visit-lover script that overlap, and there is a clear opposition in these scripts. There are more observations to be made. There is a reference to non-marital sex, so it fits in Freud's relief theory and it introduces a view on a doctor's wife behavior that does not really agree with a traditional view of her being supportive to her husband in his respected tasks. There is some degradation of her status involved and that may tickle our superiority feelings.

In the case of jokes we are usually made aware that a joke will be told. There are nonverbal cues or an announcement that a joke is forthcoming. It is made clear to the listener that what will follow is not real. In Fry [4] this has been called a 'play frame'. Apter [5], in his Reversal Theory, introduced the 'playful' motivational state that we can enter and in which incongruities are considered to be humorous. Clearly, in conversations or real life situations it is not necessarily the case that we need to be warned and prepared in order to find remarks or events humorous. We need to be aware that it is not always appropriate to introduce a humorous event and humor appreciation differs among people and cultures.

These observations deal with language humor. They don't address nonverbal aspects of humor as they are used, for example, by stand-up comedians. And they don't pretend to be valid for physical humor, humorous events and humorous situations. However, the basic characteristics can be used to look at other than language humor such as cartoons, comedy, commercials, videogames and real-life situations. No full-fledged theories are available. Rather we have case studies or global observations using these characteristics, or we find glossaries of humor techniques in which we can recognize such characteristics. We will look at them in future sections.

III. Modalities, Interactions and Failures

Humor appears in texts, in oral communication, in behavior, and in events. It is used on stage; it appears in pictures, movies, and on television. And clearly, humor appears in digital media, including social media, where it is offered in audiovisual ways on the web, in commercials on TV, the web or public displays, and in interactive entertainment environments, including games. Social robots and virtual humans will engage us in humorous interactions. In this section we have observations on the various incongruities that can occur or experienced when different perceptual experiences are addressed and different interaction possibilities can be offered. We have three subsections, one on the myriad of incongruity possibilities if we look beyond text and speech, one on face-to-face interaction with virtual agents or social robots, and a short section in which we have some notes on accidental humor.

A. Nonverbal and Cross-modal Incongruities

We have expectations when we look at a product, a device or food. These expectations can be about how it will feel, how it has to be used or how it will taste. Our expectations are not always met. That can make us confused, angry or amused. Things are not always what they seem. New digital technology, for example smart materials [6], makes it possible to change the visual appearance of a product or its texture because of changes in its environment. New technology also adds taste [7] and smell [7] to the modalities that can be used to create incongruous and humorous situations. Generally, not necessarily needing digital technology, we can have incongruities that involve various modalities. This can nicely be illustrated with products.

In [8] visual-auditory incongruities in products are introduced. They suggest that for each product an association map can be built, based on its properties. For example, a rubber ducky is associated through its scent with other plastic toys, through its color with bananas and lions, through its floating with ships, and so forth. In this way we have the possibility to create some overlap in properties and by replacing one characteristic property of the rubber ducky by one contrasting property of one of its associates we can obtain a surprising effect. Rather than have an innocent quaking of the bath ducky when squeezed, it may produce a dangerous roar like a lion. Hence, there is a visual-auditory incongruence. Another possibility, not mentioned in [8] would be to produce the scent of a banana when squeezed, another surprising effect.

From an empirical study Yu and Nam [9] concluded that there are three aspects of amusing product experience. These are the 'representational aspect' (shape, tactile, color, ..), the 'operational aspect' (its functioning) and the 'context of use'. So, here we see additional sources of incongruity. For example, a bathroom mat that seems to be made of egg scales (incongruity in shape and use), a computer keyboard that is used as key storage rack, or a key ring (to be taken from a fake socket) that reminds you to unplug appliances when you leave home.

In the papers mentioned above interactivity was no issue. With interactive products and with devices interaction incongruities can be designed. This is of course especially true with tangibles and wearables that often include aesthetic and entertaining aspects. Incongruities can include unexpected interaction possibilities or unexpected results of an interaction, comparable with, for example, the squeezing of a bath duck in the examples given above. In addition to products and devices we have human beings in real-life environments and their intended or accidental incongruous behavior is another source that adds to the possibilities of experiencing and designing incongruities.

Finally, events, whether or not including human behavior, are dynamic. They have temporal and spatial features that can be part of perceptual incongruities (for example illusions) or can be employed in creating incongruities (for example in comedy or in practical jokes). Maybe not so much in real-life, assuming that not yet fully profit is made of digital smartness, but in cartoon animations, movies with special effects, science fiction films, virtual reality environments, and videogames, technology allows humorous incongruities that we cannot yet experience in current real life situations.

When we take the step from humor expressed in language to humor in other media, in 'real' life and in particular in digitally enhanced real life we need to take into account the different modalities that play a role in overlapping scripts and in the opposition we want to see in these scripts in order to recognize or create a humorous situation. Obviously, in jokes and humorous texts situations and behaviors are described that cannot happen and understood without knowing about the existence and properties of what we can perceive and experience in the real world. But script-based theories of humor do not explicitly address different kinds of perceptual experiences and therefore in observations on overlap and opposition of scripts that describe behavior, events and situations in the real world, these different kinds of perceptual experiences do not play a role. They should be given a role in a theory that addresses more general forms of humor. Just to mention one viewpoint (or hypothesis), is there more 'natural' opposition in scripts when these oppositions are present in different modalities rather than in the same modality? That is, is cross-modal incongruity more effective, from a humorous point of view, than single-modal incongruity?

B. Interactions with Virtual Agents and Social Robots

Jokes that are read, in books or appearing on website hubs, don't allow real-time interaction at all (our laughter is not registered, it does not change the presentation of the joke, and leaving a comment on the joke on a website does not change the presentation of the joke. A joke teller uses timing, gestures and facial expressions and while doing this, takes into account some verbal, but mostly nonverbal feedback that is received from the listener. Humor in conversations includes spontaneous humor, e.g., making a witty remark that is spurred by the conversational context.

Research on virtual humans or humanoid (social) robots needs to address this behavior in order to be believable for their human partners. Virtual humans can, among other things, act as a receptionist, a museum guide, a web saleswoman or a personal assistant. A social robot can do similar tasks, but

performs them in a physical environment rather than being displayed on a screen. In both cases we have sensors and actuators. Not only verbal but also nonverbal behavior of its human partner can be detected and interpreted by agent or robot. In both cases actuators can make changes in the environment and, as most common is the case, change the virtual behavior of the virtual agent and the physical behavior of the robot.

Virtual humans, social robots and tangibles that invite us to interact with them in a human-like way need to know, among many other things, about the way we, that is, humans, support our verbal humor with gestures, facial expressions and nonverbal speech, including laughs. These are important issues in research on embodied agents (virtual humans, avatars) and social robots that are becoming part of our physical environments and that are there to cooperate with us to get tasks done in that environment, whether they are office tasks, domestic tasks or entertainment 'tasks'. Usually, however, humor theory is not considered in research on humor and robots. With a few exceptions research does not employ knowledge about the partners, the physical or virtual context, tasks that have to be performed or possible events that take place in the environment in which the agent or robot operates. But, there is some modest research on conversational humor in human-embodied agent and human-robot interaction, there is some research on body movements and facial expressions of virtual agents and robots that accompany verbal (speech) humor, and there is also research on robots that include humorous actions while performing their main task. Detecting laughter and generating laughter is another issue that receives attention, both in virtual agents and social robots research.

Equipping embodied conversational agents with a humor capacity was discussed in [10]. In particular it was emphasized that conversational agents need to know when it is appropriate to utter a humorous remark. Clearly, it is more natural to have humor in social talk than in task-oriented dialogues. In more recent years we see research emerge where humor features or humor related features are added to the interaction capabilities of embodied agents and, even more recently, to social robots. Laughter is of course one of these issues. For example, in [11] a laugh-aware virtual agent is discussed that detects laughter, including intensity, and responds with a generated laughter pattern and a corresponding facial expression. These authors also showed that in their experiments this behavior elicited positive feelings in the subjects. Virtual agents with whole body animation when laughing are discussed in [12]. But the 'why' and the 'when' are not discussed. In contrast, in [13] the ALICE chatbot has been extended with a 'computational humor engine'. Their system searches for the presence of humoristic features in the user utterances and attempts to generate appropriate humoristic answers or comments. Humor detection is restricted to recognizing alliteration, antinomy and adult slang. The chatbots' talking head presents its visual feedback using corresponding lip movements and facial expression animation. In [14] we look at constructed misunderstandings in conversations with the hope to get a humorous effect. Rather than using a linguistic analysis to solve a particular ambiguity in a user utterance, in this research the aim was to find a highly unexpected and completely wrong resolution of an ambiguity that could be used in a chatbot' s response.

Humor research for embodied agents receives much interest from educational technology researchers [15]. What is the effect of introducing humor in tutoring interactions with a virtual teacher? But, more generally, we can be interested in the personalities that co-inhabit our environments, have friendly relations with them, become friends with them, or fall in love with them. Visual appearance is important, but so is there interaction behavior and sense of humor.

Body movements while telling a joke are also investigated in human-robot interaction. Obviously, it is more interesting to look at the use of humor if the robot has a certain task to perform. Experiments usually have a Wizard of Oz setting and are meant to determine whether humor has a positive effect on the (experience of the) interaction. For example, in [16] a robot receptionist has the possibility to tell some jokes during the interaction and make it more appealing. Interesting is the research reported in [17] where a robot butler delivers objects to its owner (a participant in the experiments), e.g. a remote control or slippers. Bringing and handover of the objects can be done in a funny way. As the authors mention, there is no theory about funny behavior. So they looked at principles from verbal humor such as unexpectedness, exaggeration and self-deprecation and translated them to a behavioral level. For example, the robot suddenly pulls away the slippers when the participant is ready to take them, and makes a bantering sound. Openly gloating about his humorous behavior seems to be an important aspect of getting the humor accepted. Inspiration for finding ways to provide the robot with funny behavior was also found from watching Pixar's WALL-E movie and the 'Dinner for One' movie in which a butler repeatedly trips over a tiger fur while serving his lady. We can probably learn from other robots in Science Fiction films as well. For example, TARS in Interstellar has a cue light he can use when joking. Moreover he has a humor setting, since people don't always like his jokes they usually temper his eagerness to tell jokes by reducing the default setting.

C. Accidental and Mischief Humor

On stage, in cartoon comics, and in movies humor is intended and in sitcoms this includes the staging of laughter. Intended humor also appears in real life: the telling of a joke, performing a practical joke, making a witty remark, and so forth. Funny situations also appear by accident. The classical slipping over a banana skin and other failures of others and sometimes yourself that make you amused. Errors in automatic or human translation are also classical examples, although many that appear in the literature should be dismissed because they have been made up. Recently we saw on a minibar form together with the Spanish original the following English text: 'During your stay, we kindly ask you to sing this form daily ...'. Valitutti [18] recently looked at funny results of the autocomplete function (such as provided sometimes by search engines).

Accidental humor can happen because humans make errors or let errors happen. Stupidity is a source of errors, but so are absentmindedness, and too much curiosity. Errors can be

invited, for example if a product or an interface has been made to confuse you. Errors appear when you misuse or incorrectly use technology. In cartoon comics, comic films and comedy these errors are intended to create funny situations. In real life we can't always predict whether a funny situation will occur, although it is often funny for the observer to see someone struggle with (new) technology. In movies, but also in real life, there can be a helping hand of a 'rascal' who sets up a situation leading to a 'victim' [19]. A classical example, in one of the first Lumiere's movies is in *L' Arrouseur arosé* where a gardener is watering the plants with a hose; a boy enters the scene and steps on the hose. The gardener, occupied with his work, doesn't notice the boy and starts inspecting the nozzle of the hose to find the reason of the blockage, where upon the boy steps off the hose. There is a mediating device that has not been designed for this kind of use, but misuse or wrong use is possible and leads to a funny situation.

In smart environments there is not necessarily explicit interaction or command giving involved. The environment is supposed to anticipate our next activities and be prepared to act according to our preferences. We cannot expect that anticipations are always right. And we cannot expect that we always understand how our environment came to certain decisions, even if they are expected to follow from explicit commands. And, of course, we may give wrong commands or there are distortions in monitoring our behavior in a smart environment. These are other potential sources of accidental humor. But when sufficient humor intelligence is present then the possibility of creating humorous misunderstandings or situations, as we did in [14], is another source of humor creation. It is then the environment that creates 'mischief humor'.

An interesting viewpoint on humor in smart environments has been provided by Silber [20]. He follows Linda Stone [21] in her notion of Continuous Partial Attention. That is, we have the ability to access multimedia information pushed to us from office, social media, wearables, tablets and other devices or products that display messages. Our attention to all this information displayed to us is continuous, but also partial. We have scanning behavior, multi-tasking behavior and we try to stay a life node in the network of things. This will, following Silber's reasoning, lead to 'unintentionally muddled information', 'unintended juxtapositions', and 'mental mismatches'. Hence, a source of unintended incongruity humor.

Finally, we should mention accidental humor in videogames. Usually humor in videogames appears in canned fragments to be spoken by non-player characters in the game. It is more common to see humor appear in adventure games than in shooter games. Although canned, it is sometimes done in a very clever way, fully integrated into the game (for example, in the Portal game) and supporting or even being essential for the storyline. In this way plenty of humorous games, requiring considerable design effort, have been released. Another source of humor can be the choice of characters by the gamers. Some games allow players to choose characters with unusual appearance. In multiplayer games teams can find humorous ways to cheat and mislead an opposing team. And it may as well be fun to victimize own team members. Humor is certainly part of the communication between gamers or between audience members in the chat environments of multiparty games. A review of humor in games can be found in [22].

Videogames often contain lots of physical humor. The medium allows exaggeration and there may be different physical laws then there are in reality. Ragdoll physics, slapstick humor, strange effects when hitting someone, various ways of dramatic dying (and sometimes becoming life again), and so forth. But accidental physical humor can appear as well. This can happen when, in a particular situation, a player acts in an unforeseen way. As a consequence collision detection or the laws of physics may fail, he player may lose control and sees his avatar become victim to unknown and seemingly random rules, colliding with other avatars, making deep falls or high jumps and entering game environment parts that can't be controlled. Usually this has very humorous effects.

Apart from bugs, game design and game engines do not always hold control over all possible actions of gamers. Maybe this should be compared with real-life physical products and devices. Whatever the way they are designed, we can find weaknesses and ways to damage them. Exploring where and how game engines fail is considered to be a challenge by some gamers. It requires creative play with the game engine and exploring its boundaries, rather than focusing on the game's goals and rewards. In [23] such behavior has been compared with the mischief behavior in the early Lumiere's movies. Rather than the garden hose that is explored in a mischievous way, we now have digital technology, that is, the game engine that is explored. But usually it is the explorer, or rather his avatar, that becomes victim of the exploration. A better comparison would need the manipulation of a game engine so that someone else, for example an opponent in the game, becomes victim of this misuse of the game engine.

Sight gags are the effect of exploring game engines. In-game editors can record such sight or mischief gags and video montages where one mischief gag follows the other have been produced. This videogame genre is known as 'Machinima' and rather than just be a sequence of sight gags gamers have designed machinima where such mischief gags become part of a narrative. When looking at Machinima, in [23] four categories of humor techniques that are used by mischief video makers are distinguished: incongruity, coincidence, slapstick, and nonsense. Shift of control and contingency were additional patterns that did emerge. Disregarding the narrative and the goals of the game may lead to incongruities. Funny things may also happen by coincidence. Hence, just 'screwing around' and see what happens may yield funny moments in hours of play recordings. This may include manipulating or hacking a game's physics engine. Slapstick or controlled loss of control is often achieved by tricks that ragdollize the protagonist, that is, let him loose control over his body, rendering him as a thing. Finally, the 'nonsense' category is about the abuse of errors in the software that, for example, lead to unstable situations in which funny events happen.

IV. 'REAL WORLD' HUMOR

When speaking about 'real world' humor our first explanation needs to be what we mean by 'real world'. Do we mean the 'real world' as it existed in Plato's times where Plato viewed humor with scorn and emphasizing the negative aspects? Do we mean the ' real world' as it existed when Henri Bergson wrote 'Le Rire'[24], with its emphasis on 'mechanical humor' providing a template in which to fit human behavior or events, in order to make them look ridiculous and laughable? Freud's world maybe? In these worlds technology is available, however, and metaphorical references to this technology are made in social sciences and psychology. When we speak of the 'real world' we refer to our current physical world where indeed computers and smart technology are part of, but not yet in an integrated way we can expect to see in the (near) future, where sensors and actuators are integrated in environments, devices and tangibles that together make up the Internet of Things. Such a world should more than the current, allow playful and humorous applications of smart technology.

Usually jokes are about people and hardly included modern technology. That is, there are characters that have roles, we can understand their behavior and what they are saying and we enjoy our shift from an initial misunderstanding of a situation to an understanding of the situation, where part of the enjoyment comes from the fact that the situations are surprisingly contrasting. We can have such misunderstandings in real life. In jokes these misunderstandings are planned and language allows us to introduce ambiguous situations that make jokes possible. It is not straightforward to translate jokes to real-life events. In principle it is possible to see a doctor's wife invite her lover to enter her house (section II), but it is very unlikely we can see it, and can follow the interaction. Moreover, we have much more multimodal cues telling us what is going on than in a joke telling situation and a misunderstanding of the real situation is less likely, although not improbable. That is, ambiguities do not show, unless we want them to appear. Usually, real life does not allow us to present and experience similar situations as we can construct in verbal jokes. In contrast, accidental humor is natural, however it is certainly not the only way we can experience humor in real life situations.

As mentioned earlier, in our observations on humor in the real world we can also look at techniques that are used in language, comedy or movies since they usually, but not always, describe situations that we can also imagine to happen in real life. So, the assumption is that what we see in jokes, cartoon movies, (comedy) movies and comedy can also happen in real life. But, of course, in these media we have a joke teller or director that controls the behavior of the actors, exaggerated behavior is more acceptable than in real life, socially inappropriate behavior can be considered to be useful for its comedic effect, and clearly, in movies impossible behavior, events and situations are possible.

But, having said that, we can learn from incongruities and incongruous behavior that have been designed for these media. In particular this is true when we take into mind that also in future smart environments humor can be staged. So, we include those humor techniques that are applied in film, comedy and TV, and that deal with, maybe in an exaggerated form, with real-life-like behavior in films and comedy.

Movie or stage directors have some freedom to exaggerate, let people behave in unusual or socially inappropriate ways and they can stage events in such a way that they become funny. Laws of physics, laws of logic and laws of society can be transgressed. Moreover, they can manipulate the audience by deciding when and how the audience gets the information that is necessary to understand what's going on in the story that underlies the comedy or movie. We may conclude that analysis of humor, as it appears in on-stage or in movies provides us with information about how environments and events happening in these environments can be, and behavior of inhabitants (actors) in these environments can be used in staging a smart environment directed in order to create humorous situations.

A. Actual Life is Comedy?

When we look at research focusing on 'real life' humorous behavior and activity, then hardly scientific literature is available. Maybe we should make an exception for Henri Bergson who published 'Le Rire' (Laughter) in 1900 [24]. Bergson talked about 'Mechanical Inelasticity': "We laugh every time a person gives us the impression of being a thing." However, this idea of 'Mechanical Inelasticity' does not only refer to human physical behavior. There is physical inelasticity and mental inelasticity. With physical inelasticity there is no flexibility to adapt movements and behavior to the unexpected, while with mental inelasticity he refers to having wrong presuppositions, have 'mechanical' (sometimes absentminded) expectations and interpretations of events (see also [25]). In Bergson's view, physical and mental 'Inelasticity' may render humor (incongruity, superiority, …).

Although Bergson was influenced by what he saw in French comedy, his observations and examples of 'inelasticity' were often taken from the real world. For comedy he introduced three 'Mechanical' principles: (1) Repetition, for example, the snowball effect where a simple and innocent action starts an unstoppable series of unplanned events; (2) Inversion, for example role inversion, a child tells a grown-up how to behave; and (3) Reciprocal Interference, where different series of events (story lines) meet, have overlap, mix and are opposing. The third principle can be interpreted in terms of the incongruity theory mentioned in section II. These principles provide us with views how to analyze and create humorous situations, in comedy, in film (just starting to develop when Bergson wrote Le Rire), and in real life.

Bergson makes a useful distinction between the actors involved in the humorous event and the audience, a distinction that is also useful in real-life humorous events. Characters on stage know only part of the story; the audience can be given a more complete view of the events happening and can enjoy possible misunderstandings caused by repetition, inversion & interference. Bergson mentions that the principles can appear in real life as the product of 'absentmindedness' in characters, rather than being intentionally created. However, he also mentions that the principles provide a view on life - that may conflict with real life - as "a repeating mechanism, with

reversible action and interchangeable parts." As a consequence, having such a way on a particular event, either by stupidity, absentmindedness, or being cheated by others may lead to humorous situations or views expressed. Bergson also remarks: "Actual life is comedy just so far as it produces, in a natural fashion, actions of the same kind …" But clearly, we can help real life a little to make it more comedy.

We elaborated on Bergson's view since his attempt to provide a comprehensive view on humor in real life (although his aim may have been to describe comedy) is rather unique and useful because of the insights it offers. In Meany [25] it is noticed that by stating "We laugh every time a person gives us the impression of being a thing" he was in fact setting up a meta-incongruity, that is, if we understand Meany right, whatever the situation is, if the situation provides a reason to view, to consider or to treat a person as a thing then we have an incongruity. Climb in a mailbag and have yourself send by mail to your lover if you cannot afford the costs of a train travel. Or see Buster Keaton in an attempt to escape lose control and become a thing that slides down the clothesline from his girlfriend's house to a neighbors' house and then, unwillingly, back to his girlfriend's house (in Neighbors).

Meany also elaborates on O'Shannon's opinion that incongruity-resolution theory is "one of the biggest roadblocks to understanding comedy ever created" [26]. This section is about humor in the real world, but comedy provides the audience with situations and events that could have happened, maybe in a less exaggerated way, in the real world. For that reason it is useful to see whether principles of comedy can also be principles of real-world humor. O'Shannon rejects the 'resolution part' of the incongruity resolution theory. In the previous sections we also didn't emphasize a possibly necessary resolution of incongruities in order to have a humorous effect. What does it mean to reject the resolution part? First of all, it should be mentioned that the incongruity-resolution theory has always focused on the analysis of jokes. Although we think that incongruities underlie all humor, it does not mean that all elements of this theory need to be maintained when describing humor other than joke telling or wordplay. Moreover, O'Shannon's thoughts seem to be in line with Bergson's view when he explains his notion of 'reciprocal' or mutual interference and Carroll's [27] view on visual humor (sight gags) in films. In both cases we can think of storylines that alternately converge and diverge leading to a series of overlapping events where we have the simultaneous play of interpretations. Often the audience is able to anticipate an emerging incongruity, rather than it has to resolve one. Obviously, a director can play with the audience's expectations, he can make the audience victim of an unsuspected incongruity, but he can also make the audience his accessory by giving it more knowledge about a situation than is available for the characters in the play or movie. Not that different from the situation where streets clowns amuse their audience by surprising unsuspecting passers-by.

B. Typologies of Real-World Humor

In the literature typologies of humor techniques can be found. Techniques for verbal humor are often the starting point, for example the typology devised by Berger [28]. One of his categories is 'action humor' and although other categories contain techniques that can be used in non-language situations, only this category is explicitly concerned with physical or nonverbal humor. It contains techniques such as slapstick and chase. Hence, rather than to real life, references are made to movies and comedy. Berger's typology has been used as the basis of a typology for humor in TV commercials [29]. In this typology, making use of a study of 319 humorous commercials, we find humor techniques that are more natural for the audiovisual application domain and that deal with music, anthropomorphism and visual surprises. With principle components analysis seven higher order categories of techniques used in this domain were obtained: (1) slapstick, (2) clownesque humor, (3) surprise, (4) misunderstanding, (5) irony, (6) satire and (7) parody. In [29] it is also shown how these categories relate to the usual three humor theories.

Noel Carroll [27] discusses many different sight gags in movies, many of them in silent movies. Among them is the playing with different interpretations, making the audience 'victim' of ambiguities, or the other way around, taking care that the audience has global knowledge that is not yet available to the main interacting characters in the narrative.

In [30] there is an attempt to characterize humorous events that go beyond humorous language exchanges. He distinguishes between incongruity in 'Things' (objects, persons, situations) and incongruity in 'Presentation' (speech and language). We are interested in the former since it focuses more on situations and events that can also occur in digitally augmented physical situations and events. The main five categories he distinguishes are (with some examples, also taken from [30])

- Deficiency in an object or person. This is about physical deformity, ignorance or stupidity, moral shortcomings, or actions that fail. Hence, it is about inferiority, weakness and absentmindedness. In the case of actions that fail or performed awkwardly, it can also because of a defective tool or a chance event. In a practical joke someone is deliberately causing a failure of action.
- One thing/situation seeming to be another. This is about mimicry/imitation, imposter, pretense, and mistaken identity. Comedies often depend on mistaken identity or situation. Anthropomorphizing animals, inanimate things or sequences of events also belongs to this category.
- Coincidence in things/situations. For example, unexpected repetition in events or, for example in comedy, in lines. Everywhere we expect uniqueness unexpected repetition can have a humorous effect.
- Incongruous juxtaposition. The incongruous effect is obtained by having physical, social, and psychological opposites appear together in a situation. In a comedy team we can have physical differences (short versus tall, thin versus fat) and personality differences that help to lead to funny situations. But we can also get incongruous juxtaposition when, for example, a vagabond takes a dinner in an expensive restaurant.
- Presence of things in appropriate situations. This category can be generalized to the presence of 'things' (objects,

people, behavior, opinions) in situations where they can be considered as inappropriate, or to situations where sequences of events inappropriately intersect. Clearly, not necessarily leading to a humorous situation, but certainly helping to let a humorous experience occur.

The typologies that are available are based on the analysis of humorous situations. But, of course, they also provide information of how to design humorous situations. In a similar way we can learn from the analysis of sitcoms, TV series such as *Lucy* and *Fawlty Towers*, or films such as *Silent Movie* (Mel Brooks), Monty Python's *The Meaning of Life*, practical jokes as they appear in *Hidden Camera* programs, and failures as they appear in *Funny Home Videos*. Such analyses are available in the literature but as many other humor analyses, they have not been translated to guidelines about how to generate humor.

V. The Humor Continuum

In our future digitally enhanced and therefore smart environments we are surrounded by digital technology embedded in wearables and devices, walls, furniture, toys and artificial pets In addition there will be social robots and other artificial humanoids that can interact with us in human-like ways. Hence, this smart technology will become part of our 'real' life and we can look at opportunities this offers to introduce humorous incongruities. In the previous sections we looked at how humor can appear in various media. The assumption is and still is that we can learn from the design of humor in jokes, cartoons, cartoon comics, games, films and comedy to design humor in smart environments, using smart sensors and actuators. And we can learn from spontaneous and accidental humor in already existing interactive environments (interacting with robots and virtual agents).

In text and speech we have jokes and witty remarks. There have been attempts to the formal modeling of jokes, in particular with the help of incongruity theories. There certainly is a lack of implementations with which to test theories. From a computational point of view some theories are available (see section II) that are concerned with the formal modeling of jokes. However, this work has not been embedded and made use of main-stream research on computational linguistics and artificial intelligence, such as research on discourse representation and reasoning in computational linguistics and knowledge representation, reasoning and planning in artificial intelligence research or in artificial agents' research.

Humor in real life situations has hardly been researched. We have some typologies [29,30,31] and have Bergson's views, useful, but colored by his focus on comedy. In between text and speech and real-life behavior we have humor in cartoons with their bi-medial message, humor in cartoon movies (non-realistic situations and events), and humor in films and in comedy. In particular cartoon comics show us lots of contradictions with our usual Newtonian rules.

In comedy and films we see directors who control their actors and their behavior. Although this is staged humorous behavior, the methods used by film directors and actors can as well be used in future smart environments, either initiated by the environment or by inhabitants of the environment. In movies we can see people struggling with new technology, can we struggling with new technology and see what happens with smart technology embed in our daily environments?

We can also learn from humor in games. There are many humorous games, but a game environment also invites gamers to display a hacking attitude, in which the game engine is subject to attacks with the aim to realize unforeseen interactions, actions and game character behavior. This behavior has led to many unsuspected game situations, including game engine failures and exploitation of glitches to enter, record and edit funny situations. Again the question arises, can we use humor characteristics of game behavior in smart environments with a sense of humor? Again, the assumption is that we can control a smart environment, its sensors and actuators in a way that allows us to create humorous situations. But it also allows mischief makers to step on a 'digital hose'.

VI. Conclusions

In this paper we surveyed humor research approaches in different media and in real life. The aim was to identify approaches, whether in language, products, cartoons, movies and comedy that can be used in smart environments using smart technology. In smart environment we will have accidental humor, in particular because we will be confused by the technology and the technology does not always understand us. Humorous situations will appear because our not always successful multitasking behavior. Humor in smart environments can be intended and can make use of smart technology. We can configure smart environments such that humorous situations are likely to appear and we can configure smart environments to generate a physical 'punch line'.

In this paper we didn't discuss when and where generate humor and humorous situations with smart technology. It is not always appropriate to introduce humor in a conversation or activity. Moreover, individuals have different humor styles and there can be different reasons to introduce humor over time in a conversation or activity. Consistency in humor production is an issue [32].

The underlying idea of this paper is that in the near future we need playful interfaces, interfaces that are embedded in our daily activities such as biking to your work, shopping, attending cultural events, preparing your evening meal, and so forth. We hope that this paper contributes to the possibility of designing guidelines for introducing humor in smart environments using smart technology. And we realize that humor will try to escape from such guidelines and make them ridiculous.

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