Children and Context-aware Inclusive Tuning of Cartoons. Design of multimedia contents in an inclusive perspective[1]

Bambine/-i e sintonizzazione inclusiva context-aware dei cartoon. Progettazione di contenuti multimediali in una prospettiva inclusiva

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Abstract. Thanks to the specific characteristics of multimedia language, cartoons can transmit significant messages to viewers, both emotionally and rationally: this contribution reflects on the potential of cartoons to facilitate and support inclusive processes (also) regarding children with disabilities. In addition to examining functional strategies for promoting a more aware and more active use by all subjects, the article proposes a possible use of Artificial Intelligence to support the dialogue between Media Education and inclusive processes. On one level, the adult (educator, teacher or parent) has the task of observing the child during viewing, interacting with the child and encouraging verbalization about what has been seen: technologies can offer additional data compared to what has been observed, allowing for an even more targeted way of acting with respect to the specific needs of each child. On another level, one can use the same data to create even more interactive content that allows the narration to adapt to the specific wishes, attitudes and needs of each child. Striving in the direction of educating the media, *with* the media and *for* the media, the article promotes a conscious and critical use of technologies: useful tools for both education professionals and family members.

Keywords: Artificial Intelligence, Behaviour analysis, Context-awareness, Inclusive Cartoons, Media Education, Information and Communication Technology.

Riassunto. Grazie alle caratteristiche specifiche del linguaggio multimediale, i cartoon riescono a trasmettere messaggi significativi tra i loro fruitori, sia a livello emotivo che razionale: questo contributo riflette sulle loro potenzialità nel facilitare e sostenere processi inclusivi (anche) dei bambini con disabilità. Oltre a interrogarsi sulle strategie

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[1] The authors developed the text jointly, specifically: paragraphs I, IID and V are written by Lucattini; IIA, IIB, IIC and V by Cosimo Di Bari; III and IV by Sara Jayousi and Lorenzo Mucchi.

funzionali a promuovere una fruizione più consapevole e più attiva da parte di tutti i soggetti, l'articolo propone un possibile utilizzo dell'Intelligenza Artificiale a supporto del dialogo tra Media Education e processi inclusivi. In primis, l'adulto (educatore, insegnante o genitore) ha il compito di osservare il bambino durante la fruizione, interagendo con lui e favorendo la verbalizzazione a partire da quanto visto: le tecnologie possono offrire dati ulteriori rispetto a quanto osservato, consentendo di agire in modo ancora più mirato rispetto ai bisogni specifici di ciascun bambino. A un secondo livello, è possibile usare gli stessi dati per la realizzazione di contenuti ancora più interattivi che consentano alla narrazione di adattarsi ai desideri, alle attitudini e ai bisogni specifici di ogni bambino. Agendo nella direzione di educare ai media, con i media e per i media, l'articolo promuove un ricorso consapevole e critico alle tecnologie: strumenti utili sia per i professionisti dell'educazione che per i familiari.

Parole chiave: Intelligenza artificiale, Analisi del comportamento, Consapevolezza del contesto, Cartoon inclusivi, Media Education, Tecnologie dell'informazione e della comunicazione.

I. INTRODUCTION

The historical-cultural path that connects the Geneva Declaration of the Rights of the Child (1924, 1959), the Universal Declaration of Human Rights (1948), the International Covenant on Civil and Political Rights (1966), the International Covenant on Economic, Social and Cultural Rights (1966) and the Convention on the Rights of the Child (1989), contributes to highlighting how, over the last hundred years, the dimension of care towards the developmental age has been articulated.

From recognizing that children have the rights to be breastfed, fed, protected, not exploited, international charters and pragmatic policies have been oriented with increasing intensity towards the right to rest, the right to dedicate oneself to free time and recreational activities (age-appropriate), the right to participate freely and fully in cultural and artistic life (Committee on the rights of the child [CRC], 2013).

In appreciating and supporting what has been affirmed and systematised, we must nevertheless think about the profound criticalities and differences highlighted every year during cultural and media events that celebrate World Children's Day (20 November), also in connection with the current pandemic period (Perasso et al., 2021).

The following elements contribute to the nourishment and favoring of criticalities and differences:

(*i*) the geographical coordinates and the peculiarities of the territorial realities, both on an international scale (cultures and religions, countries in situations of peace or war, etc.) and locally (small towns, remote locations, metropolitan cities, suburbs, etc.); (*ii*) the gender as well as the composition, and the economic and social resources of the family unit; (*iii*) the school systems and more generally learning systems (formal, non-formal and informal) accessible in that specific region of the world (Fondazione ISMU, 2021). Ultimately, the criticalities and differences appear to be interdependent on that global condition of physical, material, emotional and social well-being, which is included in the concept of the person's "Quality of Life" (Felce & Perry, 1995).

Our contribution focuses on the conception, design and implementation of animation and entertainment activities in an inclusive perspective. We encounter some significant elements in the works and results published by LUDI - Play for Children with Disabilities, an international and interdisciplinary network of researchers and professionals, funded by the European Program COST (Cooperation in Science and Technology), launched in June 2014 and concluded in 2018. LUDI has pursued the main objective of spreading awareness of the importance to offer the opportunity to play to children with disabilities. The works and the results produced by the network[2] have revealed that play does not yet have a sufficiently central role in the daily practices of the educational and rehabilitation services that gravitate around children with disabilities. These contexts tend to pursue clinical objectives while opportunities, time and spaces dedicated to exploration, play and discovery activities, typical of childhood, are significantly reduced (Bianquin, 2017). Within these frameworks, play seems to be considered only a means to achieve objectives and performances (playful activities), far from playing for the pleasure of playing (recreational activities), from playing as an end in itself (Besio et al., 2017). Alongside this international path, in Italy, in May 2019, the Guarantor Authority for Childhood and Adolescence together with the Istituto degli Innocenti, carried out a study[3] that, in keeping together qualitative and quantitative methodologies, highlighted the lack of data on how children with disabilities manage their free time. All the people involved – young school students, municipal authorities, family members as well as scientific societies – in supporting the importance of play and sport in the life of children, including children with disabilities,

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[2] To learn more, see https://www.ludi-network.eu/ludi-books/
[3] To learn more, see https://www.garanteinfanzia.org/sites/default/files/diritto-al-gioco-sport-bambini-ragazzi-disabilita.pdf

underlined the lack of reference regulations and dedicated political and social planning, and affirmed the need to open adequate spaces for inclusion while prioritizing specific training on the subject.

II. CARTOON

A. Cartoon and Media Education

The use of the media represents a form of playful entertainment in constant increase by children and adolescents (Rideout & Robb, 2019). This paper considers in particular cartoons - a medium capable of re-mediating effectively during the digital revolution (Bolter & Grusin, 1999) - and how to make their use more inclusive for all users.

In the last twenty years, the television offer for boys and children, thanks to the diffusion of digital channels, has multiplied: various production companies have identified girls and boys as a privileged target, capable of also pulling a significant induction of cross-media, from publishing to merchandising. Alongside the animated films produced by Pixar and rivals, the number of serial cartoons designed for the small screen has exponentially increased internationally.

Together with the "classics" - such as *Pimpa* or *Barbapapa* – today girls and boys have at their disposal a wide range of contents designed specifically for them. A design that, if on the one hand is often based on educational purposes, nevertheless tends primarily to offer content that can be profitable from a commercial point of view. The yearly turnover of *Peppa Pig* and *Masha and the Bear* demonstrates that cartoons for children are a constantly expanding and potentially very profitable sector, but at the same time not adequately regulated. Sometimes the contents for children are full of stereotypes. Sometimes contents are not suitable for the developmental phase of childhood and adolescence, in particular if targeting preschool age groups.

Starting from these considerations, it can be understood how the cartoon represents a particularly significant mediatic text for promoting Media Education actions. It has been this way since the 1980s, when the approaches of Len Masterman, Neil Postman and other authors have invited to bring all the products of mass culture to school in order to know them better, analyse them, interpret them and make them become resources to develop a more critical and more creative relationship with the media (Postman, 1979; Masterman, 1985; Ranieri, 2011; Rivoltella, 2019).

The cartoon, given its formal characteristics, arouses a great fascination among children and young people.

For this reason, it can become a useful tool for educating *to* the media, *with* the media and *beyond* the media. With respect to media education, we can consider working on the stereotypes that are presented in them, but also on the possibilities of the narration, on the characterizations of the characters or on the commercial interests. Starting from these considerations, a training can be promoted to educate more aware spectators and, at the same time, more oriented towards the invention of stories also using multimedia means of expression. An example of the media-educational use of the cartoon can also be represented by the use of *The Simpsons*: a text that – like Orwell's *Animal Farm* – can be used for differentiated readings and interpretations according to age of the user and which can lead adolescents to formulate critical and meta-critical considerations also regarding their use of the media.

Concerning education *with* the media, the cartoon can be considered as a precious didactic resource. The richness of multimedia language and the fascination that animated images arouse in young spectators manages to deal even with complex topics, offering interpretative keys, examples, and effective explanations. Various cartoons can realize a significant didactic use from a historical, literary or artistic, but also scientific, point of view. An example is represented by the series *Exploring the human body*, which since the 1980s has offered clear and effective information materials, promoting greater knowledge about the human body and its activities.

Less frequent is the use of cartoons to educate *for* the media: this is another central task for Media Education, because it aims to promote a use of communication tools to educate subjects to live more consciously and more responsibly in the contexts in which they live. The cartoon can therefore become a tool for thinking about not only educational and instructive but also formative possibilities of the media, addressing moral and ethical dimensions that promote self-care, care for others and care for the world. It can become a "bridge" between various cross-media experiences that lead the user to compare different expressive forms, to master them not only as a reader, but also as an author. If it was already possible (and it is still desirable) to understand how analog cartoons were created (even starting from the simple sequence of sheets on a block), today it can be useful and meaningful to use digital tools to try to invent cartoons, promoting the resources that storytelling offers.

Even with respect to early childhood, the task of promoting Media Education starting from cartoons is urgent and central. The existence of thematic channels for children and the existence of contents created specifically for children often leads the parent to believe

that those contents can be watched by the child alone. The truth is that those contents often host images and scenes that trigger emotional states that are difficult for the child to manage. Moreover, before the age of three (when the time of exposure to the screens should be minimal), there is a risk that the child abandon himself to the flow of images without grasping their meaning (Tisseron, 2013). Just as an adult can be precious to educate the child in reading, it would be desirable to have a form of support also during the use of the cartoons, which intervenes by selecting the most suitable texts and which invites (gradually with age) to verbalize and carry out related activities starting from the vision of cartoons. In other words, an adult who stands next to the child and educate him/her - gradually - to, with and for the cartoon.

B. Cartoon quality criteria

Media Education, since the 80s of the 20th century, has had the goal of targeting all cultural manifestations, regardless of their aesthetic value, to promote a conscious and critical look towards media texts, but also a more creative, more autonomous and more responsible approach (Masterman, 1985). To implement Media Education through the cartoon and at the same time understand through which tools and which actions their use can be made even more inclusive, a preliminary step can be to identify the criteria to evaluate the quality of an animated content.

Although cartoons look – even respect to early childhood – as texts that can be enjoyed independently, an adult's task is to follow the child, first of all for filtering the contents, but then also to ensure that the vision is not the main goal. The vision is the opportunity to carry out other activities starting from animation, connecting to lived experiences, experimenting, playing and making the viewer a researcher.

More precisely, to be able to select more significant content, some criteria can be listed that identify elements of quality for a cartoon from the pedagogical point of view. Among these, a central aspect is the correspondence between the age of the characters and the users: in many texts (as in literature), there is a tendency to show characters older than the target audience, however this "gap" often tends to increase excessively and to show characters engaged in experiences that childhood may not fully understand (Cappuccio, 2015).

Another criterion is represented by the clarity of the narrative: this is not automatically ensured by the voiceover, which sometimes (e.g. *Peppa Pig*) can be redundant. Various Pixar short movies (e.g. *La Luna*)

that do not use verbal language are anyway extremely clear: the clarity is given by the linearity of the scenes and by the ability to compose an effective syntax between the images.

A third quality criterion is represented by an adequate relationship between music and images. Various cartoons present rhythms similar to action movies, in which the editing of the shots is interlaced with sound sequences aiming to stimulate suspense: in these cases, the risk is to immerse the user in a state of excitement that makes understanding more complex.

A fourth criterion can be represented by the use of metaphors. In all narratives metaphors have a precious cognitive role because they push towards the world of elsewhere, because they allow to tell complex themes with clear and effective messages and because they stimulate a deeper thinking as well as the imagination. A narrative that uses metaphors can also deconstruct insidious stereotypes that, unfortunately, often hide in many texts for children (Antoniazzi, 2015).

Finally, a fifth significant criterion is represented by the ability to discuss precious values for childhood: for example, about friendship, collaboration, respect for the environment, care for objects, self-care, care for others and for the world. Among the cartoons currently broadcasted in thematic channels and in various on-demand platforms, there are many examples that could be exemplified on the above cited criteria, demonstrating on one hand a growing sensitivity with respect to some criteria, but at the same time also the aim to maximize the audience, even at the expense of the quality.

C. Cartoon and difference: promoting inclusion through cartoon

Among the media contents that can be used with children to discuss about the inclusion, the cartoon represents a precious resource: in fact, it not only possesses an enormous charm that can be channelled towards meaningful thinking, but at the same time it can speak naturally and easily even about complex and profound topics. Some reasons for this charm effect of the cartoons are obvious: their ability to stimulate perceptive abilities through colours, sounds, music, and voices which – especially in the latest generation cartoons, but also in the classic ones – capture the attention of the spectators. In addition, there is also their ability to intercept topics that feed the curiosity of boys and girls, dealing with captivating and engaging topics, situations, and emotions.

Trying to analyse specifically the texts that are most successful among the cartoons designed for the television, we can identify their ability to be settled in plac-

es that are both reassuring (such as familiar ones) and stimulating (such as fantastic contexts that feed the imagination). At the same time, a recurring tendency is towards the characterization of characters that ease the identification.

In the previous paragraph, we referred to criteria that can make a high-quality cartoon. In particular, in order to make an animation content useful for promoting inclusion, it may be necessary to add two other criteria: the first refers to the representation of the difference; the second refers to the use of stereotypes.

First of all, it is important to select cartoons that are able to make us think on the difference, leading for example to understand that it is dangerous to put in contrast normality and diversity, instead of showing how the difference exists in each of us and must be respected, protected and valued. The examples on the big and on the small screen during the last ten years (from *Finding Nemo* to *Luca*, from *PJ Masks* to *Vampirina*) demonstrate how the pedagogical sensitivity around the difference is constantly increasing even among cartoon producers and screenwriters (Felini & Di Bari, 2019).

At the same time, however, it is necessary to proceed with an analysis of animated contents that can lead to the selection of narratives that do not have stereotypes that simplify reality, trivialize and generalize the difference, ending up to misleading visions of the world. Although this is not a concerns only of cartoons (see e.g. adult television programs, commercials and even some illustrated books), in planning an inclusive educational intervention it is important to select cartoons that do not include prejudices and stereotypes in representing the difference.

Disney has thought about these topics: in 2020 its web portal reported a note against the vision of some of its classics to children under the age of seven, because of the presence of cultural and gender stereotypes. Concerning the disability, although the sensitivity of many narratives is growing in recent years, a preliminary filtering by the adult is appropriated in order to avoid that children under the age of six are exposed to these stereotyped narratives. Even with age groups over six years, it is possible to use the tools of Media Education to deconstruct stereotypes and prejudices, forming more critical viewers and, therefore, more responsible citizens, stimulating the construction of a more inclusive and democratic society. This is a task that also concerns disability: if on the one hand it depends on the producers of content for children, on the other it can also go through the planning of specific interventions that educate to be inclusive and stimulate forms of education for children to / with / beyond the media.

D. Cartoon between Reasonable Accommodation and Universal Design

The concepts of *Reasonable accommodation* and *Universal design* in the Article 2 of the Convention on the rights of persons with disabilities (CRPD) (United nations [UN], 2006) can represent the starting and the ending points of evolutionary paths towards sustainable and universal orientations, respectively. The first refers to changes perceived as necessary and not particularly burdensome, but at the same time useful for guaranteeing rights and freedoms to people with disabilities. The second emphasizes the ability to design products, environments, programs, and services as broadly as possible that can be used by all people, without having to require specialized adaptations later on. Let us try to combine these two concepts with examples of animation and entertainment activities, designed or adapted in an inclusive perspective.

An example of *Reasonable accommodation* is represented by the "AutiTec" Project promoted by the Institute for Scientific Hospitalization and Care (IRCCS in italian) "Eugenio Medea", Polo di Bosisio Parini (LC)[4]. In order to find research strategies to foster and support the interaction skills of children with autism spectrum disorders, the project[5] aims to develop a series of high-tech solutions, easily accessible (also in terms of cost) and for daily use (applications, tablets, PCs, TVs). Specifically, the project focuses on:

– implementing remote tools and platforms to support rehabilitation programs traditionally provided by the IRCCS and related to the home management of children with autism spectrum disorders;
– by using an online database[6], collecting and classifying applications for children with autism spectrum disorders, their family members, and people involved with them in their daily educational, recreational or sports experiences, following an ecological and systemic perspective;
– stimulating relational and social skills of children with autism spectrum disorders through a personalized and technologically innovative use of the television, in particular in the interpersonal game between parent and child.

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[4] In collaboration with Rai Ragazzi, Rai CRITS and the Turin Production Center, and in partnership with the ASPHI Foundation onlus, the Lombard Regional Cluster Foundation for Technologies for Living Environments which promotes and disseminates innovations for fragility. To learn more, https://emedea.it/medea/it/news-it/388-2-aprile-per-la-giornata-dell-autismo-c-e-la-pimpa
[5] The project was presented within the webinar Applications and cartoons: digital initiatives for autism available at https://www.youtube.com/watch?v=NZO8Ros6LNI
[6] To learn more, https://www.appandautism.it/

Following the purposes of this contribution, let us examine this last macro-objective. To answer the question "how can we contribute to make a cartoon a functional tool for the social interaction of children with autism spectrum disorders?", the working group involved in the "AutiTec" project identified some methodological criteria and collected them into guidelines. Together with contents and educational messages appropriate to the reference age, the cartoon should ultimately:

– explain and emphasize aspects that can help young children to understand the emotions and moods of the characters, as well as the motivations and intentions that guide their behaviour[7] (for example through the use of a marked facial expression of the characters);
– limit the use of metaphors and ironic attitudes (the story of the episode should be fluid, with clear and direct connections between the various situations represented within the individual scenes);
– present captivating but not chaotic stimuli, with an adequate rhythm (neither too slow nor fast) within the story and synchronizing visual information with linguistic information.

The next step was to analyse RAI's television production with the aim of finding a cartoon that could satisfy the greatest number of identified criteria. The cartoon *PIMPA* was found to be the one with the most suitable characteristics.

As a further and final project action, the working group developed an application to facilitate the understanding of the cartoon by children with autism spectrum disorders. The application, not yet on the market, allows the subject to interact in three different ways:

– to pause the cartoon, thus recognizing the opportunity for children to see it again in complete freedom;
– a still image (preceded by a sound) appears at the critical points of the episode (for example when one of the characters is about to perform a certain action but the reasons why the character is about to do it are not explicit), offering children verbal clues, hints and stimuli useful for understanding what is about to happen;
– viewing a summary of the episode through a sequence of images representing the different crucial moments (each of the images is also associated with a narrating voice with the function of synthesizing what is happening at that particular moment).

An example of *Universal design* is represented by the series "Lampadino e Caramella nel Magiregno degli Zampa", created by the company Animamundi in collaboration with Rai Ragazzi. The TV series, consisting of twenty episodes lasting six minutes each, tells the adventures of Lampadino and Caramella (brother and sister), together with their friend Zampacorta, son of King Zampasaggia, within the fairytale setting of Magiregno degli Zampa.

With the aim of creating an accessible, usable and fun animation product for preschool children with and without disabilities, specific linguistic and stylistic choices have been made within each episode:

– a narrative scheme is repeated episode after episode, giving the story a predictability that generates in the child a security linked to the knowledge of what will happen next;
– the use of "live-action" scenes in Italian Sign Language (LIS in Italian), thanks to the presence of interpreters placed in speech balloons and appearing near the character who is speaking[8];
– the constant presence of subtitles, which are decisive and functional linguistic-communicative tools both for children with auditory sensory disabilities who do not use LIS, and for children with a migratory background[9] who are not fully confident in understanding Italian grammar;
– the presence of settings and characters with a very simple and minimal drawing to allow children with visual sensory disabilities to perceive and recognize actions, outlines and scenes more easily;
– the presence of a voiceover with the function of filling the absence of dialogues between the characters and describing the aspects necessary for an autonomous, complete and correct use of the episode even by children with visual sensory disabilities;
– the use of audio-stories that narrate the individual episodes;

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[7] Within everyday social interactions, it is tiring for children with disorders in the autism spectrum to understand the emotions and moods of other people (Cottini et al., 2017).

[8] The presence of interpreters is not limited to the linguistic facilitation function. The same interpreters imitate the characters present in the cartoon on a behavioural, emotional, postural level but also on an aesthetic level, using similar clothing, hairstyles, tricks. This strong and structured correlation between interpreters and characters offers, for example, to children with hearing sensory disabilities, the feeling of belonging to the story, the feeling of being at home (Gardou, 2016), which are decisive features to promote the realization of an inclusive society.

[9] With the expression "migratory background" (Accorinti et al., 2018) we refer to different situations:

– second generation young foreigners (G2), or born in Italy to parents both born abroad;
– young Italian children of mixed couples, or born in Italy but with a parent born abroad;
– young foreigners of the first generation, or born abroad to parents born abroad;
– unaccompanied foreign minors (cases of adoption / fostering).

–   the absence of disturbing elements such as particularly strong lights or sudden loud sounds;
–   a limited use of noises and music;
–   the use of a high quality but non-invasive sound commentary.

Together with the strategies designed and implemented in the above-mentioned cartoon, that give the cartoon a high degree of inclusiveness, we must also highlight how the series was conceived with a strong pedagogical-educational imprint, where the differences of the characters and points of view are considered as potential riches, where otherness, friendship and respect constantly play a central role. The educational value is evidenced by the UNICEF 2020 award received by the series in December 2020 at the International Festival of cross-media animation and TV for children "Cartoons on the Bay", promoted by RAI and organized by Rai Com.

III. ICT SOLUTION FOR CHILDREN AND CONTEXT AWARE INCLUSIVE TUNING OF MEDIA CONTENT

Information and communication technologies (ICTs) have been always seen to be a support for social inclusion (Manzoor & Vimarlund, 2018), in particular when children with disabilities are targeted. ICTs can be used for several purposes: from education (school e-inclusion) (Ott & Pozzi, 2009) and rehabilitation (Shalash et al., 2018) to playful and entertainment activities (van den Heuvel, 2018; Lucattini et al., 2019). With the support of ICTS during play and entertainment activities, many skills of children with disabilities can be improved, such as motor, cognitive, sensory, communicative, learning, social and leisure.

Focusing on education to the media, with the media and for the media, ICTs can represent a new language/tool to support children and their families, as well as teachers and educators, in the fruition of media contents.

The proposed solution aims at promoting Media Education actions through the adoption of ICTs for creating inclusive and adaptive media content tuned based on the children's real-time needs.

The target of this study is the autonomous fruition of cartoons through the design of an adaptive system that transparently guides the children, enhancing their experience and awareness of the media contents. This can represent a key element for education and it allows the tuning of the animation content in an inclusive perspective.

The objective of this section is to provide a high-level description of how ICTs can be used to inclusively enhance the media content fruition by children. In particular, starting from the analysis of the cartoon quality criteria, the proposed system functionalities are detailed together with the architecture components and user interfaces.

A. System Requirements and Functionalities

The starting point for the definition of the proposed solution was the analysis of the main cartoon quality criteria, which can be seen as the user requirements. As better described in Sections II.B and II.C, these are: i) correspondence between the age of the characters and the users; ii) clarity of the narrative; iii) use of metaphors; iv) adequate relationship between music and images; v) ability to discuss precious values for childhood (friendship, collaboration, environment respect, care for objects, people and the world) ; vi) representation of the value of the difference; vii) removal of the use of stereotypes.

Although the cartoon content should be created following these criteria, the different application contexts and the children's needs may vary during their daily activities and lives in general. This requires an additional focus on the children's needs and consequently an adaptive and aware tuning of the cartoon content.

The main functionality of the proposed solution can be summarized as: children and context aware inclusive tuning of the cartoon content. To better explain this approach some potentialities of the system are listed in the following:

–   Data gathering and processing for children and context awareness
–   Children behaviour analysis during the fruition of the content
–   Transparent tuning of the cartoon content based on advanced algorithms
–   Implementation of an adaptive cycle-process consisting in a continuous data gathering and processing.

B. High-level Design of the ICT System Architecture

In order to give an overview of the overall functioning of the proposed solution, in Fig. 1 a high level design of the ICT architecture is depicted. The system consists of four main technological components:

1. Data Collection Component. It allows the data gathering from environmental and wearable sensors. Different kinds of data related to the child's behaviour and the surrounding context (environment, presence of other people or children, etc.) are col-
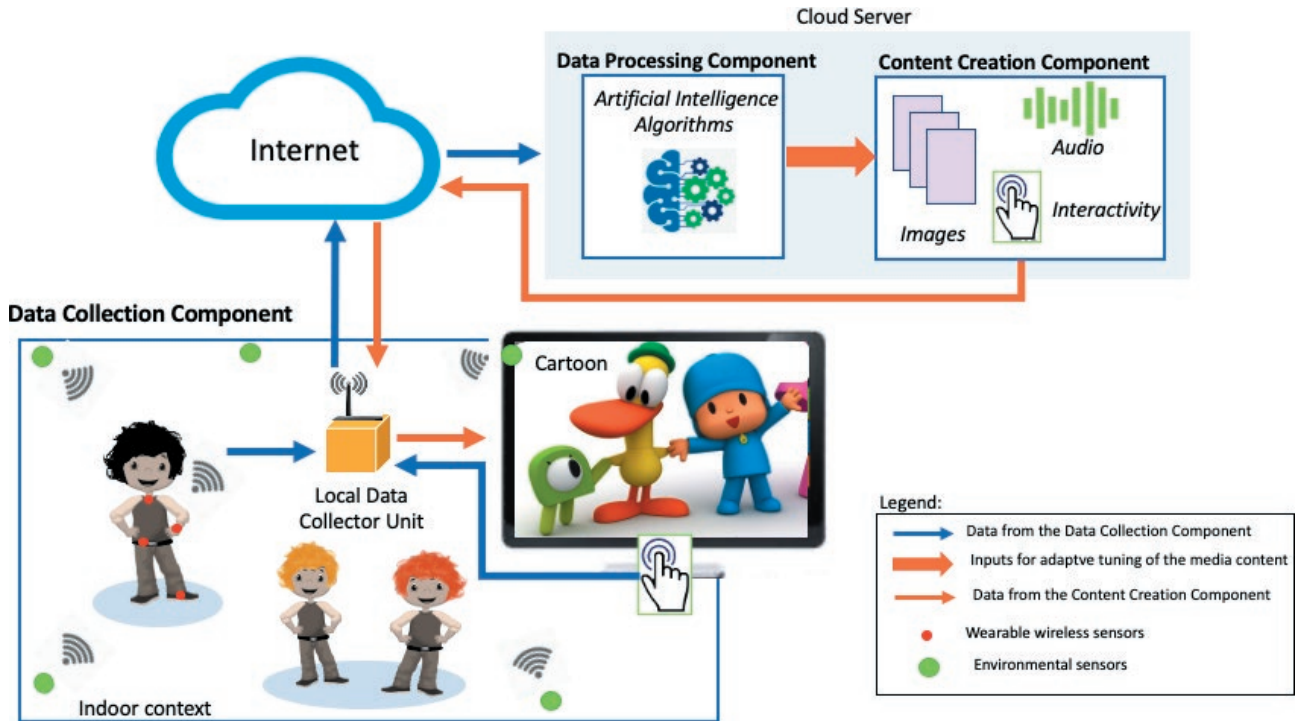
Figure 1. High level design of the ICT architecture for Inclusive Tuning of Media Content.

lected. Child's bio-metric indicators and physical activity parameters together with sounds and videos are gathered and transmitted to the cloud server which hosts the data processing unit.

2. Data Processing Component. It is in charge of the advanced processing of the collected data and it consists of an AI (Artificial Intelligence) Engine which is the core of the proposed system and it is hosted in the Cloud Server. It provides real-time inputs for cartoon content tuning based on the child's profile and behaviour analysis, as well as specific context identification.

3. Content Creation Component. It is represented by the media content creation system, which is in charge of modifying and delivering the cartoon based on the input received by the data processing unit.

4. Data Communication Component. It consists of the telecommunication network infrastructure, the proposed system relies on for the data exchange among the network nodes involved in the system architecture.

The integration and the interactions among the above listed components enable the implementation of the cartoon content inclusive tuning based on the child's needs and the surrounding context.

C. Adaptive Real-time Media Content Delivery

The overall functioning of the adaptive tuning of the cartoon content creation can be synthetized as follows. Moreover in order to better highlight the main components and the interactions among them, Fig. 2 provides a block diagram of the proposed solution.

Child's emotion-related indicators and context surrounding data are transparently and continuously collected by the advanced sensors of the monitoring component. Wearable sensors worn by the child provide information about sensory perception, biomedical parameters, and motion activity. Non-invasive sensors integrated in belt, watch, glasses, necklace, or shoes are available in the market and can be used to gather different kinds of information ranging from child's visual and auditory perceptions to biomedical emotion-related data (skin sweat, heart rate, body temperature, blood pressure, etc.). Moreover, motion sensors allow gestures, body poses and motion activities recognition (sitting down, lying down, standing, walking, running, etc.). Finally, location and environmental sensors are considered for context identification, including both physical ambient parameters (such as temperature, humidity, lighting, noise) and presence of other people or children, their locations and their interactions.
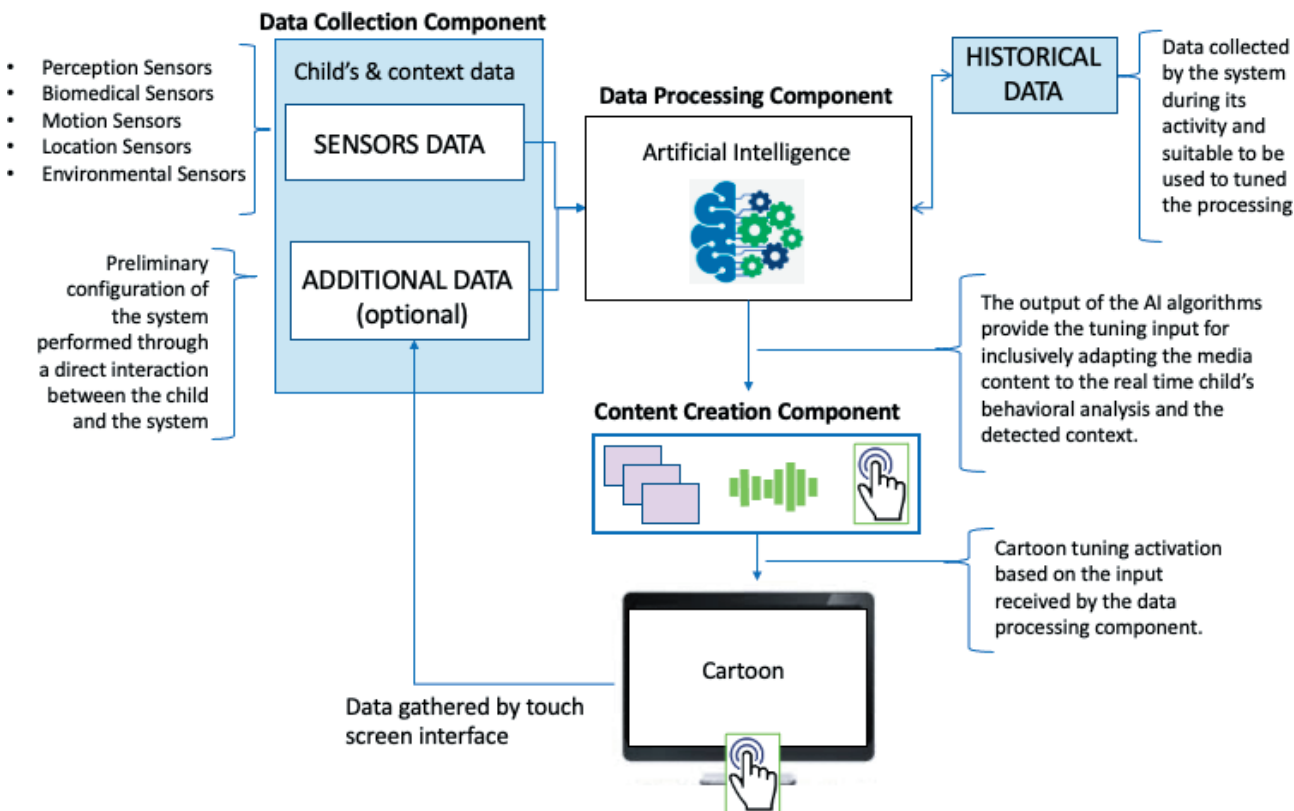
Figure 2. Block Diagram of the proposed solution.

It's worth highlighting that additional data can be collected through a direct interaction between the child and the Cartoon thanks to the adoption of smart devices (including touchscreen, echo dot stations, etc). In particular this interaction can be adopted for an initial configuration of the system, where the cartoon is automatically selected based on a set of questions the system asks to the child or to an adult the child is with. The child answers can be also performed by gestures detected by the wearable and environmental sensors.

All these data are locally aggregated by a local collector device to reduce the amount of data to be exchanged and then they are sent to the Cloud server for advanced and further processing performed by the AI Engine. The AI algorithms are in charge of processing those data and providing the inputs for the cartoon content tuning based on the real time detected child's behaviour and context.

The outputs of the AI engine represent inputs required by the content creation component for adapting the cartoon content to the identified needs and situation. These may involve: i) image changes; ii) audio guide introduction for supportive or interactive purposes; iii) audio/music tuning (e.g.: volume, sounds notification for catching attention, melodies tuned based on the images or characters mood); iv) content changing based on the acquired context information (e.g.: the presence of a child and his/her friends may be the input for proposing contents on friendship values).

The automatic tuning inputs resulting from the AI Engine relies on a preliminary training of the algorithms performed through adequate data sets coming both from the monitoring sensors system and from the already available experience-based information provided by media experts and educators. AI plays a fundamental role in the implementation of the behaviour analysis and in the identification of the tuning of the content in an inclusive perspective. Social inclusion oriented dynamic processing and interactive and adaptive mechanisms are two of the key elements for the definition of the cartoon content changing inputs.

As the inputs are defined the content creation component activates the requested changes to the cartoon content in a "smooth way" and without impacting on the overall cartoon vision. This requires a preliminary definition of a dynamic content creation that allows a transparent tuning of the cartoon. Once the cartoon is modified based on the acquired data, the loop starts
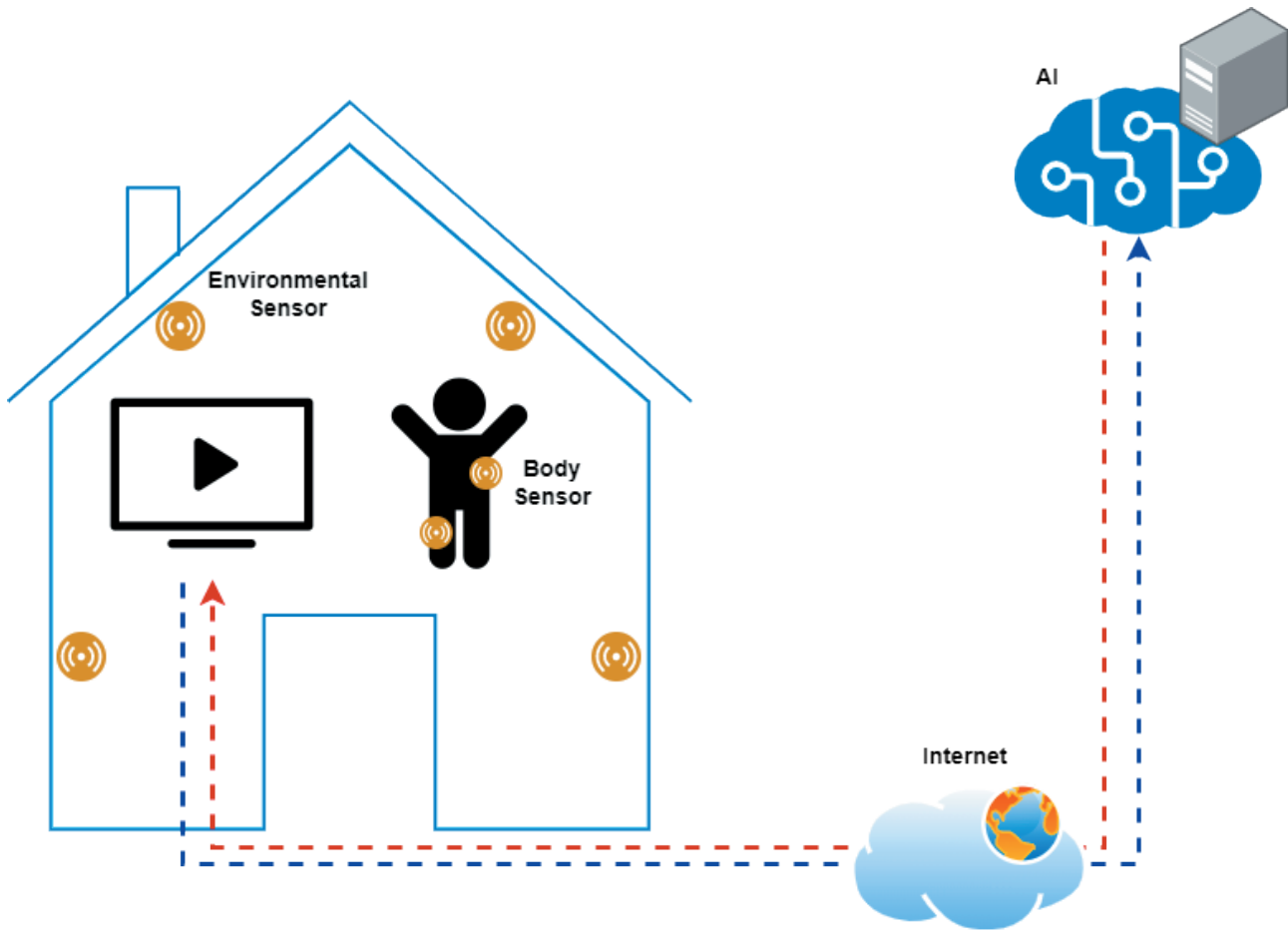
Figure 3. Double feedbacked system of the proposed solution.

again: the child's behaviour and context monitoring system continuously provides real time data to be processed and therefore the child's reactions to the cartoon tuning will represent new inputs for the AI Engine and consequently provide both data for new changes activation and additional information regarding the system functioning (e.g: does the performed tuning obtain the wanted results? What can be improved in the tuning mechanisms? etc.). While the former are needed to let the system adaptation mechanism continuously work, the latter are fundamental for data sets creation and for improving the system response to a large variety of events.

IV. TECHNOLOGICAL CHALLENGES

Although many advances have been already carried out in the field of ICTs for social inclusion (Njoki & Wabwoba, 2015), many challenges have still to be addressed, in particular when the role of ICTs is focused on media content design for children with disabilities. Internet-of-Things (IoT) and artificial intelligence (AI) can bring an important support for real-time dynamic content adaptation. IoT sensors could be used both on the body of the subject as well as in the environment to collect data on the children during the fruition of the media content. Sensors could measure different parameters, from body movements to vocal stress, from position of the body with respect to the media content to heart- and breath-rate. From raw data, information can be extracted which gives us the possibility to define a behaviour of the children during the vision of the media content. This information can then be used by AI to modify the media content in real-time, thus adapting the content to the specific needs of the specific child during the vision. What we have just mentioned represents a challenge from the ICT perspective. The double feedbacked system (Fig. 3) could be hard to be implemented and maintained by today's ICT infrastructure, but the research is going ahead very quickly in this field.

V. CONCLUSIONS

The use of technology in an educational setting should neither represent a delegation nor a replacement in terms of functions belonging to the human being: making a cartoon educational and inclusive is, first of all, a human task, for which specific pedagogical skills are necessary to plan contents, to accompany children while they watch the screen and to expand the experience of storytelling by doing other activities related to the story.

This proposal considers ICT as tools that can work in synergy with the human being, allowing to integrate observational activities and traditional interactions also with data collection. At the same time, with a view to offering personalized content, the proposal can make it possible to study an expansion of narrative possibilities, offering content and proposing methods of viewing that are tailored to the specific needs of children. Quoting Umberto Eco, the child can be allowed to "get lost" in the narrative woods (Eco, 1995).

Proposing an "inclusive" cartoon can therefore begin from the creation of contents that already in terms of themes are able to promote a vision of difference as a resource; but, with a view to an active, conscious, critical, creative and responsible use of technologies, it also means ensuring that the human being is in a position to prepare an environment that is more open, more comfortable and more stimulating for all children.

Among the current challenges facing Media Education, we can also identify that of turning the media into allies of the human being in the task of promoting more active, more responsible, more critical and more inclusive uses of screens.

With the conviction that the search for inclusiveness represents a collective enterprise (Booth et al., 2006), this "alliance" should be expressed both in the school environment, with educators and teachers who educate *to*, *with* and *for* the media through careful planning, but also in the family environment, with an involvement that informs and trains parents, making them active protagonists in the task of promoting the digital citizenship of their children. The objective may therefore be to overcome the traditional relationship between content producers and users, promoting a circular relationship in which a participatory dialogue is established between the design, viewing and accompaniment to carry out activities that use the cartoon as a "pre-text" and then carry out other instructive, educational and training activities.

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