The Battle of Cannae: Towards a Model of Immersive Visits through Massive Use of Character Animation

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The Battle of Cannae took place near the Ofanto River in Puglia and was the biggest battle of the Second Punic War. As a result of the events connected to it, Rome could become an imperial republic, master of the *ecumene*, or the known world of the time, or give in to the dominion of Carthage forever. At the dawn of August 2, 216 BC Hannibal gained an overwhelming victory, but the final outcome of the war, as is well known, ended definitively with the victory of the Romans under the guidance of Publius Cornelius Scipio at Zama in 202 BC. Rome thus gained control of the entire western basin of the Mediterranean, which would have decisive political, social, and economic repercussions that would be fundamental for the fate of not only the future empire, but also of the peoples overlooking the Mare Nostrum. The Battle of Cannae is recognized as "the battle par excellence", the war strategy made it into schools, studied by militaries of all time periods, but is described by many with significant differences in interpretation. So within a renovated Antiquarium, the direct study of the sources is combined with the use of technologies of representation and communication to offer new visitors the opportunity to musealize those events, the protagonists, and the political and social conditions in context. With the new exhibition, the museum opens up to a more dynamic and participatory vision of the public, attempting to become a cultural attraction capable of triggering virtuous processes of knowledge transfer thanks to the potential of new digital languages. The development of immersive content merged into the movie Apud Cannas, combined with thematic in-depth analysis on touch-screens provides diversified content for a heterogeneous public, which includes specialists, history experts and a "general public", who has low knowledge of the history of Cannae. In this project, the approach of a simplified user-experience, useful for audience with low confidence with technologies, contrasts with the content created with the most innovative technologies for museum communication.

INTRODUCTION

The Battle of Cannae took place near the Ofanto River in Puglia and was the biggest battle of the Second Punic War. As a result of the events connected to it, Rome could become an imperial republic, master of the *ecumene*, the known world of the time, or give in to the dominion of Carthage forever. At the dawn of August 2, 216 BC Hannibal gained an overwhelming victory, but the final outcome of the war, as is well known, ended definitively with the

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victory of the Romans under the guidance of Publius Cornelius Scipio at Zama in 202 BC. Rome thus gained control of the entire western basin of the Mediterranean, which would have decisive political, social, and economic repercussions that would be decisive for the fate of not only the future empire, but also of the peoples overlooking the Mare Nostrum [Brizzi 2016, McNab 2011]. There are still many uncertainties about the precise location of the place where the battle took place, but the most reliable hypothesis identifies it with the eastern plain of the Ofanto River, near Barletta (Bari, South Italy). Here, in the valley of the Basso Ofanto, the settlement of Battaglia delle Canne stands on the hill, surrounded by mighty walls and inhabited for several centuries. Today the site offers visitors a long and fascinating route that includes the remarkable remains of the Roman, early Christian and medieval periods on the so-called "citadel" and finally the ancient Daunian village with the burial ground in Fontanella. In the Antiquarium, a little museum near actual city Barletta[1], the substantial nucleus of archaeological material documents the long continuity of life in Cannae, from Prehistory to the Middle Ages and with its new redevelopment, it was inaugurated on August 2 2017. The whole project was promoted by the Regional Secretariat of MiBACT, the historical memory of the epic battle is returned to the public with involving and immersive solutions, in order to recount the events that took place in that summer of 216 BC.

Fig. 1. The Roman army exiting the castrum, with the centurion, signifer, and cornicen in the foreground.

APUD CANNAS, A PROJECT OF CULTURAL INTERPRETATION

The Battle of Cannae is recognized as "the battle par excellence", the war strategy made it into schools, studied by militaries of all time periods, but is described by many with significant differences in interpretation. So within a renovated Antiquarium, the direct study of the sources is combined with the use of technologies of representation and communication, to offer new visitors the opportunity to "musealize" those events, the protagonists, and the ancient political and social context, all this through dramatization, description and representation. The new museum is opening up to a more dynamic and participatory vision of the public, proposing to become a cultural attractor, capable of triggering virtuous processes of knowledge transfer thanks to the potential of new digital languages. A project has been launched that involves the development of immersive self-explanatory content, combined with in-depth thematic analysis on touch-screens (Figs. 5-6) to provide a diversified product to a heterogeneous public, in which a simplified approach to user-experience, without obvious technological ostentations, is contrasted with content created with the most innovative solutions for the service of virtual archeology. In short, the user can make both passive and active use, where technology is not visible, but becomes the essential element for learning, entertainment and having fun. In the first (passive) mode, a film lasting about 17 minutes transfers information in a visual form, entrusting the cultural message to the narration, which uses methods of cinematography and techniques of Computer Animation to emotionally involve the viewer, but in a framework that is scientifically consistent with historical information and known archaeological evidence. Although it may seem simple and obvious, this solution is in line with modern learning dynamics. It is in fact a common opinion that the emotional and immersive involvement given by historical re-enactments presented in three-dimensional form can exert an incisiveness on a communicative level that is superior to any other media and therefore this can definitely qualify as an important way of learning. We could define it to some extent as an inverse path, which starts from reconstruction and re-enactment,

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[1] http://www.puglia.beniculturali.it/index.php?it/113/luoghi-della-cultura-statali/35/parco-archeologico-e-antiquarium-di-canne-della-battagli

in order to produce interest. The reconstruction, which represents the final moment of a philological study, is presented to encourage the visitor to read and study the same sources from which the re-enactment comes to life. The cognitive contribution given by visual communication is in general decisive for the purposes of knowledge and enhancement of Cultural Heritage, but perhaps it is even more so for the understanding of those complex events, which involve a long and careful study. For these reasons the Battle of Cannae is presented in the Antiquarium in narrated form, with technological aids that allow the visitor to relive the events in person, to understand the military organization of the two armies, the clothing of the protagonists (Figs. 1-3) and the cultural and social dynamics and issues related to the battle itself. The film therefore represents the starting point towards an ever deeper knowledge, up to the point of arriving, through the use of the applications developed on touch-screen, to the philological reading that emerges from the complete transcription of the sources. The events told are in fact taken largely from the writings of Polibius and Titus Livy, who describe in detail all the events of the battle and the portraits of the protagonists. A second touch-screen will consist of the visit of the citadel in a Virtual Tour mode. Once again, the multimodal approach to realization has been chosen as an element of recognized validity to allow for diversified learning, declined in the different forms of visual communication both passive and active.

Fig. 2. Roman army inside a castrum.

THE VISUAL COMMUNICATION

The dramatization in animated form of the Battle of Cannae brings with it some interesting openings on the script of the story, articulated in a rhythmic way, with different references in Latin.

"To bring war to Italic soil, to arrive in Rome, this is the strategy of the Carthaginian leader Hannibal who, with a march of fifteen hundred kilometers, from Gades to the Rhone, to the Alps, begins an unprecedented undertaking. The devastation of Italy appears in a dream and is similar to a snake of marvelous grandeur. His army started from the Iberian territories with 90,000 infantrymen, 12,000 horsemen and 37 elephants, but the price to pay is very high in human losses and sacrifices. Less than a quarter of his army, arrives at the plains of northern Italy frozen, hungry, and exhausted,. But the terror of the Carthaginians, the metus punicus, is more real than ever in the Roman Republic. The defeats of the Roman legions are costly at the Ticinus, Trebia, and Lake Trasimenus, leaving the peninsula in flames between 218 and 217 B.C."

Ours is not the first representation of the battle at all. Many scholars have tackled the same subject and there are many CG animated resources available on the net today, made with different techniques and styles[2]. Most of these develop essentially around the dynamics of the battle, or on the different possible options, as an alternative to the most accredited ones. There are three main historical accounts of it, but none are contemporary. The closest to the events is that of Polybius (200-124 BC), written about 50 years later. Titus Livy (59 BC. - 17 AD) describes it at the time of Augustus, while Appianus of Alexandria (95 - 165 AD) speaks of it even later. After the discussion on the reliability of The Histories of Polybius, our interdisciplinary workgroup developed a story that could provide a clear and concise framework of reference for the political conditions of the context, while at the same time telling the

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[2] https://www.youtube.com/watch?v=UhCX9BXnook
https://www.youtube.com/watch?v=0KOxdc9-FT4&t=219s
https://www.youtube.com/watch?v=V-QJZ1X8LSg

battle beginning with its protagonists and the moves of Hannibal. What are the reasons for the war? What are the reasons for the defeat? What are the differences between the two armies? But above all, what language should be used in the telling? The main device was the story in the third person, but with some artistic quotations that could develop a certain curiosity in the visitor [Titthasiri 2013]. Artists of all periods were often interested in these events, the mythical figures that took part in them, and the epic enterprises, such as the crossing of the Rhone, the crossing of the Alps, and the use of elephants in battle. So, together with the scenes reconstructed in computer animation, we accompanied the narration with paintings (Figs. 7a-7b) and illustrations transformed into 3D through decomposition for planes and contoured figures that occupy the three-dimensional space in depth, giving critical sense to the details. Stereoscopy gives even greater interest to the reinterpretation of pictorial work without distorting its meaning [Gabellone 2015].

Fig. 3. The Carthaginian army on the front line. In the foreground is the proposed reconstruction of Hannibal.

Fig. 4. An example of massive character animation in Adobe's AfterEffects di Adobe. There are circa 40,000 agents.

On the contrary, it accentuates the pictorial connotations and historical value. Precisely in relation to the need to achieve maximum communicative efficacy, combined with a quick and concise narration, space was given to non-verbal description, mainly built on the richness of the images [Huizinga 2006]. The high evocative value of the reconstructions brings out many details on which the vocal commentary deliberately lingers, but which are effectively described visually without the need for further aids. Many scholars of eidomatics or expressive languages, such as Ernst Gombrich [1999], have often valued the digital image, or non-verbal communication [Schooler and Eich 2000], as a fundamental element in cognitive processes and of great value as a historical document or depositary of historical truth. In fact today we live in an "image-based society", not in the sense that more meaning is attributed to appearances with respect to content and meanings, but rather that communication seems to pass more and more through photos, videos and images within society in general [Anolli 2002]. The image that we invested most heavily in was the clothing of the characters, which were faithfully reconstructed on the basis of historical information, especially from Polybius' The Histories and archaeological evidence. In the App present on the Antiquarium TouchScreens the protagonists are all presented interactively, with a 360° rotation, complete with textual descriptions of details, though in the animated story they participate in the narration without any

descriptive emphasis. It will be the curiosity and interest of the visitor that determines the search for more in-depth information [Zyda 2005].

Fig. 5. Grab-screen of the App. This is conceived as an in-depth analysis of the contents displayed on the video.
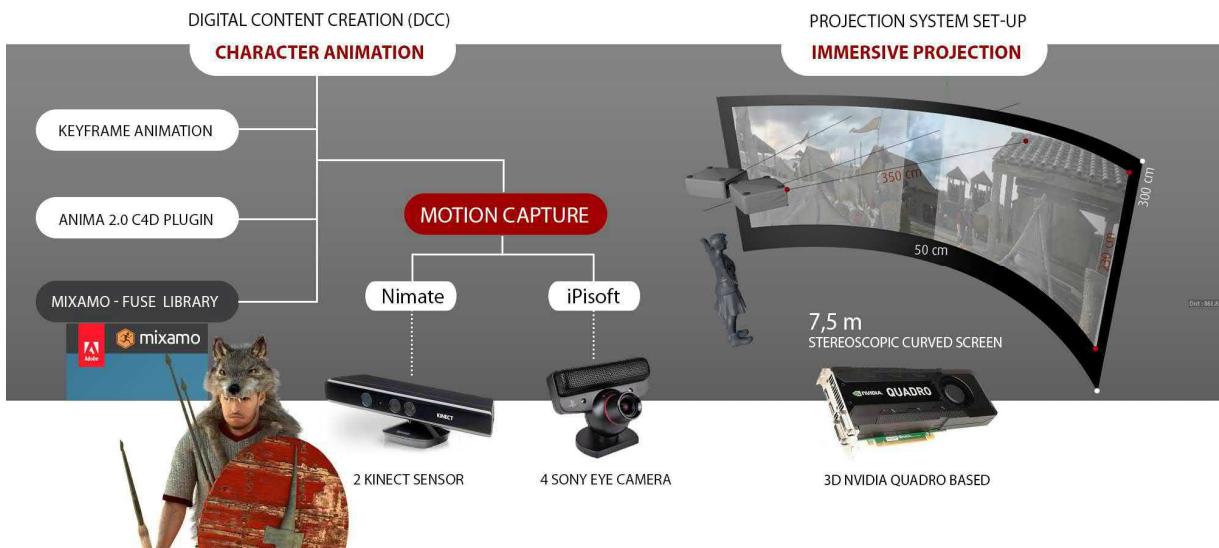

Fig. 6. A synthetic workflow of the project.

TECHNOLOGICAL SOLUTIONS FOR THE REALIZATION OF HISTORICAL RE-ENACTMENT

The technological solutions adopted for the film are characterized by two relevant aspects: the first concerns the creation of digital content, the second concerns the set-up of the projection system, which we will discuss later. As already mentioned, the film stems from the need to create immersive, emotional participation. It is mainly distinguished by two aspects: the adoption of stereoscopy and the use of character animation, in some scenes

realized with a very large number of agents. Large production houses have many robust character management systems, some of which are expensive at the professional level, others that are very simple but equally interesting. In this project we mainly used three methods of animation: the first uses classic animation based on keyframe, the second uses a free motion capture system for Kinect Sensor[3]. The third uses motion libraries available on the Mixamo platform[4]. Many of the solutions described here do not in and of themselves constitute an advancement of knowledge in this specific field. However we believe that the experience of using robust technologies, available in part for free, can serve many users for the simplified development of content based on character animation [Kelly 1998]. In fact, the element of greatest scientific interest in this work is perhaps the methodology of philological research that takes shape and substance thanks to the contribution of technologies that do not require a very high level of specialized skill.
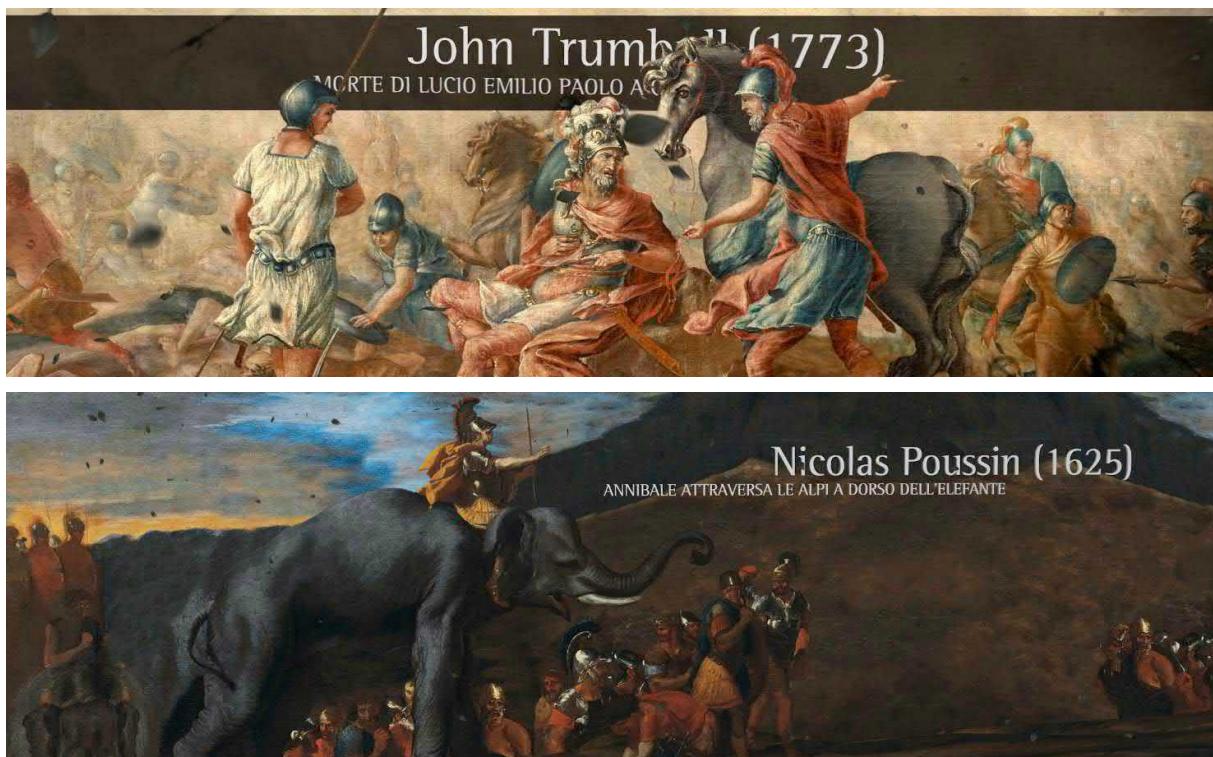
Figs. 7a-7b. Three dimensional animations of 2D paint at the interior of the story.

Motion capture systems

The motion capture system used here is Nimate, a real-time cross-platform and cross-sensor motion capture suite designed to be used without any IT skills and iPisoft, commercial software. For the use of Nimate no marker is required, nor any complex or expensive configuration. The system uses Kinect for Windows (gen2) and Kinect XBOX 360 (gen1), which, associated with a bones system, within the modeling and animation environment, detect movement in real time. The same features are found in a lot of commercial software, such as iPisoft, which we used as a comparative testbed. The final results are very good, without the typical defects due to abnormal keys, or degenerations in the capture of the movement. Some scenes are visible from the project trailer here: https://www.youtube.com/watch?v=cLWfSQCiYXE.

It must be noted that the previously mentioned free Mixamo libraries allow one to associate motion capture movements on a humanoid imported into the platform, preferably in fbx format. The set of these technologies, some with the possibility of open programming, some commercial, others free, covered the primary animation needs

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[3] https://it.wikipedia.org/wiki/Microsoft_Kinect

[4] https://www.mixamo.com/#/

required for this animated film, where the dynamics of the characters, their facial expressions, and their management in numerically consistent masses, represents the central element of the story. A simple expedient was used for facial expressions, which allows one to associate, in any 3D modeling software, a live facial movement with morphing points on a 3D model of a human face [Gabellone 2017]. The technique, often used in cinematography, is actually very simple and makes use of the modern motion tracking algorithms present in numerous SWs. Adhesive circular markers with dimensions of 3-5 mm are placed on the real face near the areas of greatest expressive movement, such as the contour of the mouth, the eyebrows, and the base of the chin. The live shooting of the movement and the subsequent tracking of the markers is associated with the corresponding points on the 3D model. A simple script, in our case Xpresso, native to Maxon Cinema 4D, allows one to perform this association, paying attention to local and global references. The global transformation coordinates of the markers become the movement coordinates of the 3D facial morphing points.

Fig. 8. Crowd simulation. An example of interactions between different groups of characters.

Crowd simulation

The last technical element of interest concerns the management of crowds. As is well known, this aspect requires the use of extremely expensive software, generally used in large productions. Here we used two gimmicks. The first fully 3D was made in Maxon Cinema 4D with the use of a particle emitter. These give the possibility to detect collisions and above all react in a "smart" way to dynamic events. We used only four different agents in as many groups of particles that, moved on a spline, gave very good and realistic results. A second trick, this time 2.5 D, was made in Adobe AfterEffects (Fig. 8). Here too a particle system, to which previously animated characters with an alpha channel have been associated, has allowed us to animate about 40,000 characters at the same time, though the total number could easily be doubled on a PC with good computational capacity. It is all in stereoscopy, with two distinct sequences for the left and right channels. The result, shown in the figure below, gives us proof of the validity of this solution, which is economical yet very realistic and effective. In this process we must not consider the complexity of the clothing of soldiers irrelevant, as it is very often made up of multiple overlapping layers, such as swords, spears, and knives, all with dynamic movement associated with the main skeleton. The work is certainly complex, with various problems, but at the same time interesting for the many possibilities offered today by the technological panorama, even in the absence of large economic resources. A last solution was used for crowd generation in close-up shots. For these, we used the Anima 2.0 software[5] integrated, as a plugin, in Maxon Cinema 4D. This software allows today to build your own agent and to program precise behaviors of crowds, such as collision, path, etc.

Stereoscopic setup

No less important than the management of the characters and their clothing, was the hardware setup necessary for stereoscopic projection in the Antiquarium of Cannae. The projection had to include a large curved screen (about 7,5 m in chord length) and a projection that did not hit the visitors standing in front of the screen. The solution resulting from these needs was to use two short focal stereoscopic projectors, combined together in a warp and blending management system. This need has been solved via software, for the control of distortion on the curved surface and

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[5] https://secure.axyz-design.com/anima-crowd-simulation-software-home

the nuance in the overlapping area of the two distinct projections, in order to generate a unique image, without distortions and without artifacts due to overlap. As is known, this type of installation, with a very large curved screen, can only be realized with a compatible hardware that is usually very expensive. In this museum we used two NEC PX602UL projectors combined with a PC equipped with NVidia K 4000 graphics card. This configuration has caused serious operational problems, as the proprietary technology that allows one to obtain a unique image with multiple projectors (NVidia Mosaic) is not compatible with the stereoscopy supported by our hardware. So we developed a simple, but ingenious system that circumvents the problem and makes everything work in a stable, flawless manner. The solution consists of managing the projection inside the Stereoscopic Player software in window mode. This is because the full screen mode makes the video run on the main screen only, leaving the second without projection. The use of some scripts permitted starting the application in window mode, but with a window of predetermined size, slightly larger than the overall size of the two screens. In this way the projection extends regularly on the two screens and no command is visible during the projection. The solution described here operates the warp and blending software system correctly, keeping the stereoscopy in sync on the two projectors (Fig. 9). The end result is perfect, with no artifacts or sync problems, and shows that multiple screens can be used in stereoscopy without dedicated hardware, as opposed to some specifications released by graphics card manufacturers.

Fig. 9. Real image of the curved screen. The parliamentary secretary Dorina Bianchi visit the Antiquarium.

CONCLUSIONS

The particular technical solution described here has allowed for the realization of a very immersive installation that is the main premise of all our work. With the film *Apud Cannas* we have tried to produce a simple, exciting, communicative, and scientifically coherent medium. The keywords could be: easy information, effective communication, high level of realism, involvement of young people and finally original hardware configuration. Naturally, these are only the basic presuppositions, i.e. those necessary to start the project. But the real interest in 3D technology is the ability to represent the battle with its protagonists, around the cultural world that characterizes the times of the Punic Wars. Apud Cannas is similar to a passive book, which should arouse curiosity and inform the public in a concise way, from which it is possible to begin a more in-depth study. Interesting animation technologies of the characters have allowed us to manage a battle that until recently would have required abundant resources, with many specialists and large investments. The project was received very positively by the public, demonstrated by a great increase in visitor numbers and, above all, by a renewed interest in the battle. For this, the museum has set up a quick questionnaire (which should be prepared in digital format, we hope) for a simple evaluation. The film is: clear, exciting, engaging and instructive, tiring. With four levels of evaluation, from poor to excellent, the public can evaluate the experience.

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