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Short Paper

Interactive Digital Narrative Authoring Tools and Hybrid Experiences in Cultural Heritage: An integrated review

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Abstract

Interactive Digital Narrative Authoring Tools (IDN-AT) are software applications that allow users, without the need for programming skills, to create, design, and publish interactive digital narrative applications. In the field of Digital Heritage and specifically in that of Virtual Museums there is an increasing need of such tools, to enable non programmers (designers, creatives and curators) to design and develop hybrid experiences in cultural contexts. This paper aims at reviewing available solutions, defining the gaps and still missing features, tools or services, with the goal of paving the way for a webXR integrated solution.

CCS Concepts

Human-centered computing → *Interaction design process and methods;* ***Empirical studies in interaction design****;* • ***Applied computing*** → *Arts and humanities*

1. Introduction

In the current scenario of digital transition, Cultural Institutions are increasingly requiring easy-to-use and accessible tools that enable them to design and deliver meaningful applications that include on one hand 3D, XR and hybrid solutions, on the other should involve engaging approaches as Interactive Digital Narratives' (IDN) mechanisms (e.g. linear / non-linear stories). A clever solution is the adoption of Authoring Tools (ATs) [CMFP02]. ATs are in fact software that can be used by an interdisciplinary team to generate a wide range of applications starting from static multimedia assets (images, sounds, videos, 3D models) with a minimized need of technical programming skills. But although ATs provide a comfortable approach to digital creation, complex experiences that fully integrate IDN structures and hybrid technologies are still a hard goal to achieve without coding-expertise. IDN approaches rise in complexity in the Cultural Heritage field, due to the need to manage different data formats, including 3D reconstructions, semantic and geospatial layers, and high-resolution details. Moreover, meaningful experiences require emphasis on tangible and also intangible factors, such as cultural significance, historical context, emotional resonance, intellectual and aesthetic value [MCB*14]. In order to fulfill their specific needs, Cultural Institutions often cooperate with research institutes and/or with creative industries, spending remarkable efforts to create new custom solutions from scratch. In fact, even if several ATs exist - varying in terms of purpose, coding requirements, user interface and extensibility - they do not seem to satisfy the needs of such complex and domain-specific interactive experiences [GHC18b]. For the purpose of this work, we use "Interactive Digital Narrative

- Authoring Tools" (IDN-ATs) referred to software applications that allow users, without the need for programming skills, to create, design, and publish interactive digital narrative applications (digital stories that allow the user to participate and influence the outcome of the narrative through interaction with the media). With "Hybrid-Oriented ATs" (HO-ATs) we intend authoring platforms that allow users to create 3D-based interactions and technology-enhanced experiences such as immersive environments and augmented reality applications. Are included applications that use Internet Of Things (IoT) as a relevant factor in user-experience.

2. Objective

The aim of this work is to survey existing tools (developed by academics and industry, open-source and commercial software), define and compare critical factors (e.g. end-user output, degree of customization and user-friendliness) in order to provide a framework that highlights current solutions and lacks for convenient improvements. This research proposes a mixed-method approach that combines a review of ATs' existing classifications with a comparative analysis of critical factors (e.g. features, accessibility, interoperability) focused on the intersection between IDN-ATs and HO-ATs. This combination supports the definition of a conceptual framework, whose aim is to provide a comprehensive perspective on the available tool's capabilities, identifying gaps and opportunities.

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3. Methodology

To provide a comprehensive overview of IDN-ATs and HO-ATs, following 5 macro-categories have been defined based on principles of purpose and technology, inspired by the ordering criteria of the extensive ATs' dataset of Shibolet and Knoller [SL22]:

1. Consultation
2. Interactive Fiction / Visual Novels
3. Serious Games
4. VR and MR exhibitions / museums
5. IoT-enhanced experiences

In order to achieve a comprehensive assessment oriented to investigate users' needs, following criteria have been defined: ***End- user output*****:** identifies the kind of output that can be created using the tool (including quality of end-user engagement strategies, depth of content, type of medium). ***Degree of customization*****:** describes the flexibility of the tool in terms of features that allow output experience's adaptation considering the author's needs. ***Usability*****:** defines if a tool can be easily adopted by designers and creators who may not have programming skills, or it requires a significant learning curve. ***Availability*****:** informs about the types of license or subscription needed and if the tool is freely available and/or open source. ***Compatibility*****:** describes how the tool allows to integrate other technologies and platforms, such as AR/VR, digital archives as 3rd party services. In order to deconstruct ATs' features in meaningful cluster of parameters and visualize their impact on the above mentioned aspects, a further abstract classification is proposed based on following three perspectives: 1) *Technology*: express how different technologies are integrated in end-experience; 2) *Information Architecture:* describes the complexity and abstraction level of the AT's data-structure exposed to the author; 3) *UX/UI:* describes what kind of contents are proposed, the interactions involved, the navigation mode, if and how end-user actions have influence in the experience. A data-visualization model has been created as a human readable framework to allow comparative analysis and further research. This analysis and model would have an impact also in the definition of an ideal workflow, suited to design an IDN / Hybrid exhibitions.

4. Exploratory Analysis of ATs

This chapter presents few meaningful examples of ATs that require little or no coding skills, representing different existing typologies and described in terms of their purposes and components. Relevant cases are arranged in a progressive complexity order, offering a gradual exploration of the subject matter without aiming to provide an extensive review of ATs.

4.1. Consultation tools

These tools aim to generate digital products with the purpose to navigate hyper-textual and multimedia contents through layouts and views that present data with predefined user interface items (we don't include CMS or code-based web utilities - e.g. Viewshare - considered professional solutions out of target). This category includes tools for end-user experiences that display content through image-based Points of Interest (POIs) as CurioPublisher*;* map-based POIs as Mapbox and ArcGis- StoryMap; mixed-widgets stories such as HistoryPin or TumultHype.

4.2. Interactive Fiction / Visual Novel tools.

Born as text-based experience, Interactive Fiction (IF) is a relatively simple form of IDN. For this purpose, ATs such as Twine and Inklewriter provide a visual interface that includes graph-editor and block templates, designed to compose linear and non-linear narratives. The story evolves through branches, depending on the end-user's choice during the experiences. The priority of managing graphic elements increases in Visual Novels ATs, as Ren'Py, based on mark-up language. ATs such as TyranoBuilder and Wool also combine 2D backgrounds, characters, sounds and dialog systems, providing an easy-to-use visual interface. Other tools, still in their beta-versions, improve the user-experience of the creative process such as the web-based tool Narralive [VKK*19], or CAT (the Chess Authoring Tool, developed by the EU project [VKK*14]).

4.3. Serious Games tools.

Representing the highest level of complexity of IDN-ATs, these tools aim to create full adventures with complex interactions, inventories, navigation maps, scenarios, characters, game mechanisms [Dub16]. The interface of these tools is often articulated in several views, control panels, assets libraries and more advanced graph-editors, as noticed e.g. in GameMaker Studio, Bladecoder Adventure Engine, Construct and PlayCanvas. Tools such as ItyStudio, that manage 3D characters, are also considered as Learning Management Systems tools (LMS).

4.4. VR and MR exhibitions / museums tools.

Exploring HO-ATs, recent research in 3D/virtual ATs is achieving different goals including visualization of 3d assets from different devices, navigation and interactions utilities in VR and AR [CMG*22]. This category includes platforms for 3D, Virtual Tours and more complex VR/AR experiences. Platforms for 3D are solutions that enable the user to achieve full navigation of 3D assets through desktop/mobile standard gestures, presenting the result on line, such as Sketchfab and p3d. Interactive 360 Virtual Tours ATs prioritize virtual first-person exploration, often from different devices. These tools allow to create virtual itineraries through 360 panoramas including spatial oriented call-to-action (CTA) triggers for content overlay. (e.g. Pano2VR, Panoraven, Orbix360, Kuula, Klapty). With a growing 3D digitization know-how required, Virtual Exhibition ATs allow to place and interact with digitized artworks in a web-based virtual environment (e.g. MatterPort or research prototypes as Invisible Museum) [ZPK*22]. More powerful ATs provide flexible configurations of VE (lights positioning, textures, materials, preset or customized virtual location) such as OccupyWhiteWalls. Following a Virtuality- Reality Continuum, VR/AR ATs simplify software/hardware infrastructure and allow an accessible approach to MR projects that would otherwise require remarkable efforts and time [RLMT16]. VR- ATs aims to manage assets, animations and interactions in immersive experiences as CenarioVR and IrisVR. Hybrid approach includes AR ATs, used for generating AR experiences based on different devices

(e.g. hand-handle and Head-Mounted-Display, HMD) and various types of tracking modes, including marker- based and markerless. Tools such as SparkAR, Vuforia Studio, Layar, Wikitude Studio allow to display and animate 3D models in AR. Commonly these tools provide a simple interface to configure 3D triggers for predefined CTA. Other Hybrid approaches have been studied by the GIFT EU project and a demo with API is available with MIT license. Another increasingly important factor is the collaborative approach that involves different technology such as VR and IoT projects, often for maker-based educational purposes [CMMB19, ASN22a, ASN22b, WLS08].

4.5. IoT-enhanced experiences tools.

The current evolving *phygital* approach increases the need for seamless interactions between virtual and physical elements [DK22]. With this aim, utilities that can allow to simply integrate Internet Of Things (IoT) technology in CH digital experiences are crucial. Indeed this technology included different solutions to assign virtual behaviors to physical objects, creating hybrid experiences that include tangible elements and digital environments. In this direction, IoT ATs cover a more limited range of cases including geolocation-based (e.g. SPIRIT); tangible experiences through proximity-based interactions such as beacons, RFID, nfc (e.g. meSch), motion controller and projections [KS17, PND*14, CCA20].

5. Discussion

From the analysis of 4.1 and 4.2, Graph, text and forms represent the most diffuse types of AT's authoring interfaces and each of them impacts differently to usability, power and content-fidelity [GHC18a]. As also reported by Spierling and Szilas [SS09], considering IF, it appears quite critical the unrealistic expectation of authors who approach an AT for the first time. Often the authors manifest hesitance to accept the idea of condensing the story writing activity into an unfamiliar data-entry process: obstacle mitigated by adopting a multidisciplinary workflow. Furthermore, common UI/UX liabilities refer to icons not easily recognizable, missing standard undo-redo commands, unclear messages of error- handling: lacks addressable throw UI/UX design user-centered implementation.

In 4.1, 4.2 and mainly in 4.3, a lower abstraction level of ATs is reported as a conflictual factor that even increasing customization (allowing a more flexible definition of functional entities), impacts on learnability [KMSG20]. On the opposite side, a rigid formalism (with fixed data-structure) is easy-to-use but limits the breadth of variations. Nevertheless, there is an attempt to simplify serious game creation, thanks to the adoption of design guidelines [LMH*22].

HO-ATs (4.4, 4.5) represent a recent domain compared to IDN-ATs: even if VR, AR and IoT are technologies increasingly integrated in CH experiences, ATs still expose a very limited range of interactions [MRRDAS18]. Designing AR/VR story-driven experiences represents a complex challenge due to the unpredictability of the physical surroundings, which directly influences the user's attention span [ABM*20].

There is indeed a lack of debugging/user-simulation utilities or user-friendly guidelines that could help to design such complex experiences. A significant effort is also required to search for appropriate ATs solutions, as a deep understanding of the state-of- the-art is necessary. Other missing features include customized gestures, speech-based interactions and input from external sensors [NS18], all of potential high interest for the cultural domain.

ATs that merge HO and IDN approaches refer almost exclusively to research projects, prototypes and genre-limited tools such as CHESS (narratives in AR), Virtual ShowCase (AR projections), BlocklyXR (visual coding for XR experiences), GIFT (co-design of tangible narratives), TrainAR (story-driven AR for learning, built on top of Unity), AR Nuggets (indoor AR navigation, built on top of Unity).

To conclude, ATs' proliferation is more evident considering isolated categories whereas there is still potential for further development of consolidated ATs that allow to fluidly converge IDN and HO features. Only with coding skills - using more advanced Game Engine (e.g. Unity and Unreal) or open source frameworks such as ATON - is possible to achieve an all-in-one approach. [FFD*21].

Declining the tradeoffs regarding Educational ATs also discussed by Murray [Mur04], following principle summarize AT's intrinsic factors:

a) AT's *power* can be described as a relation between *breadth* of potential output and *depth* of specialization.
b) AT's *usability* (including *learnability* and *productivity)* is strictly related to AT's *complexity*.
c) Complexity refers to the number and composition of abstracted values, objects and structures exposed by the AT.
d) Power and Usability are usually at odds with each other, as well as Breadth and Depth.

Comparing the above presented principles with ATs' analysis is possible to establish a concrete relation between key factors and ATs'properties: power is mainly related to the number of possible configurations of technological components, the range of game / narrative / educational features and the user-engagement/ graphic quality of the output of an AT; usability is mostly influenced by the knottiness of the visual tool, the level of abstraction (impacts negative if it is managed through a non-user friendly tool), the presence of helpers and utilities (e.g. error handlers and debugging), the availability of example projects and documentation.

In order to visualize ATs' properties and their impact, 15 descriptors have been defined as components for the conceptual framework. Each descriptor identifies a collection of properties. The descriptors are grouped in three main sections as follows.

[Technology] section includes: *Virtuality* of output (AR/VR/XR inside a virtuality/reality continuum); *Display* (standard screens, projection, HMD); *Interface* (mobile/desktop gestures, virtual controller, sensors, speech); *IoT (*Nfc, Rfid, bluetooth, GPS location); *Collaboration* (online session and shared logic); *Software Output* (deploy strategies, debugging/simulation utilities, OS-limitation); *Ownership* (cost, license, API, interoperability).

[Information Architecture]: *Multimedia* (plain-text, HTML tags, images, videos, panoramas, 3D model, animations, audio); *Type of*

tool (graph-editor, text, form, block, pseudo-code, parser); *Level of Abstraction* (instantiable entities, customizable properties, configuration of behaviors); *Game Mechanisms* (state consistency, conditions, story/level structures, game logic, environment graphics and settings); *Data-structure* (database access, ontologies, model-view relation).

[UX/UI]: *Engagement* (quality of experience, game- mechanism, meanfulness, granularity of informations, story evolution); *User-role* (depth/effectiveness of the user-interaction, navigation role, reward system); *Graphics* (fidelity of content, animations, look-and-feel quality). To achieve a human readable result, each descriptor has been represented as an infographic *descriptor module* (Fig. 1). This module aims to display its order of complexity (or immersivity) and visualize its impact on the final evaluation of the tool.

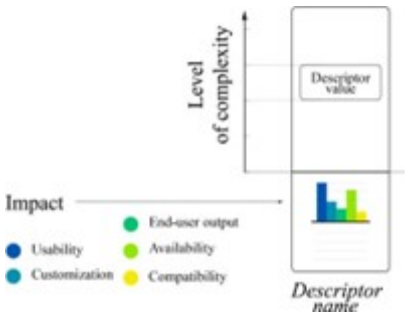

Figure 1: *Descriptor Module explanation*

The conceptual framework is composed of descriptor modules and the next example illustrates it through an use-case that requires a comparison between ATs. Starting from design brief: "Creation of an interactive narrative guide (visual audio) for visitors of a museum, using their smartphone or pc", following three ATs have been identified as eligible tools to fulfill the needs of the project : *Narralive*, *Twine* and *CurioPublisher.*

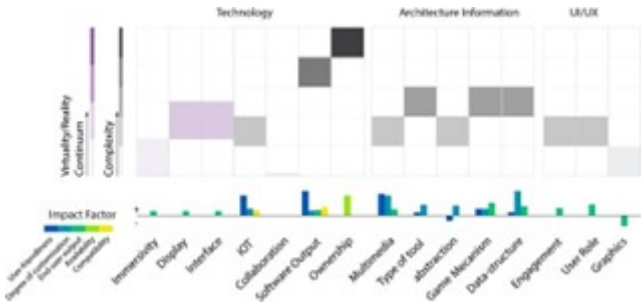

Figure 2: *Simple conceptual framework visualizing Narralive*

Gathering the impact factors, we can visualize a radar diagram to facilitate a comparison among the three ATs:

6. Conclusions

With this research it has been possible to elaborate a conceptual framework based on ranges of purpose, features, usability, technology and coding requirements of ATs. This operation allowed us to identify current lacks and issues in the intersection between IDN-ATs and Ho-AT, defining a shortage of easy-to-use ATs that properly combine both approaches. Although a simplified version has been presented, we are currently working on the development of a complete framework for a deeper analysis including sub-sections that explicitly show the relation between properties and impact factors. Starting from this perspective, future improvements can be achieved by exploring more consciously possible interoperability between tools and designing new solutions through technical and conceptual reverse engineering.

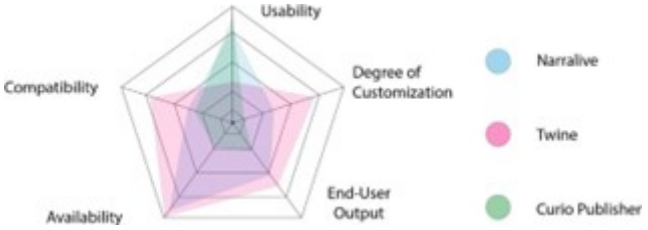

Figure 3: *Narralive, Twine, CurioPublisher*

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