A Novel Production Workflow and Toolset for Opera Co-creation Towards Enhanced Societal Inclusion of People

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***Abstract*— Opera uses all the visual and performing arts to create extraordinary worlds of passion and sensibility. It is rightly recognised as a great achievement of European culture. And yet a form that once inspired social and artistic revolutions is often seen as the staid preserve of the elite. With rising inequality and social exclusion, many see opera—if they think of it at all—as symbolic of what is wrong in Europe today. This paper presents the technological and scientific approach of the European H2020 TRACTION project that aims to use opera as a path for social and cultural inclusion, making it once again a force for radical transformation. TRACTION wants to define new forms of artistic creation through which the most marginalised groups (e.g. migrants, the rural poor, young offenders and others) can work with artists to tell the stories that matter now. By combining best practices in participatory art with media technology's innovations of language, form and process, the project is defining new approaches to co-creation and innovation, exploring novel audiovisual formats based in European cultural heritage, such as opera.**

***Index Terms*— Media innovation as incentives and tools to reduce poverty, enhance inclusion; Design driven innovations in Media and Creative industries (interfaces, usability, accessibility, inclusion, education, end user orientation, interactivity, human machine interfaces, visual innovations, data protection by design); Interactive, Immersive, and Social media; Accessibility (inclusion, cross-media).**

I. Introduction

INEQUALITY is the defining issue of our time, as politicians from Barack Obama to Jean-Claude Juncker have recognised. It constrains the lives and chances of millions of European citizens, and makes it harder to address existential threats like global warming. Because inequality is visible and experienced in daily life, it also makes the easy promises of populists seem attractive. The distance that most people feel from elite culture might not seem the most urgent of social inequalities, but its symbolism is powerful. Europe is a cultural space or it is nothing. Unless its citizens share, and feel common ownership of, the culture that expresses what are lightly called 'European values', there is a real threat to the most successful peace-building project we have known.

Opera is the unavoidable heart of this challenge. A cornerstone of European cultural heritage, opera has always spoken to both elites and people, expressed both authority and revolution. Its colour, passion, beauty and drama have inspired generations. But in recent decades, this art has too often lost sight of its popular roots and radical edge. European Opera may be economically and artistically valuable, with a turnover of €5 billion, a permanent workforce of 50,000 and over 15,000 performances each year. It may be the total art that includes every aspect of practice, the theatre of emotion that aspires to transcendent and universal artistic experience. It is certainly the form that gets most public subsidy for music, and the one that reaches least beyond the wealthy sections of society. Research shows that today's typical spectator is a 54-year-old woman with higher education, who travels by car and spends an average of €159 on her evening of culture.

Opera is in danger of becoming a symbol of European inequality but – crucially – it also has the capacity to rewrite that story, to include those left behind in wider prosperity, to renew itself and so find the energy, the resonance and the heart to be once again the root of living culture. Achieving that means working on three things at once.

First, it means using new ideas of co-creation and participatory art to involve citizens in the creative process – and to prioritise those who are currently marginalised or ignored by opera: the poor, migrants, people living outside dominant cities or in institutions, disabled people, those of non-white heritage, in short, the majority of our fellow citizens. This means going much further than making opera accessible, though that is always important. It means empowering people and communities to become creators in their own right, to tell the stories that reflect their lives and resonate with their neighbours, to express their version of European values, to become active citizens, with agency and a meaningful right to be heard in the national cultural conversation.

Secondly, it means releasing the form, language and aesthetics of opera from the stuffy museum in which it has too often become trapped, not through glossy and surface changes

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(which are common enough as it struggles to be ‘contemporary’) but through brave experiments with music, performance and art. Unless opera learns to speak a language that excites people again – without imitating those easy promises of populism – it is destined for a future of irrelevance.

Thirdly, it must embrace new technology both for the new possibilities it is rapidly creating all around us, and as a means to achieving the first two goals. What can digital technology, immersivity, virtual reality, the internet, interactivity, social and media innovation bring to the process of co-creation? What can they bring to the artistic language of opera and the ways in which artists connect with audiences?

This paper presents the technological and scientific approach of the European H2020 TRACTION project [1], which is designing and developing a collaborative and participatory production toolset, establishing a novel workflow for the co-creation and co-design of operas. The research includes a front-end that provides conversational support for community dialogue, tools for user-generated rich media capture, such as immersive audiovisual and 360-degree content, smart media editing mechanisms, narrative engines and interactive adaptive media distribution technologies, that will produce interactive audiovisual content to support traditional opera formats, and explore novel audiovisual operatic and art representation formats.

The TRACTION toolset will provide a bridge between opera professionals and specific communities at risk of exclusion and it will be tested on three trials, understood as experimental attempts, to foster an effective community dialogue between diverse individuals and collectives on each one of the nodes: community opera with migrants (around LICEU at Barcelona), opera co-creation with young inmates in prison (driven by SAMP in Leiria) and bringing a novel digital opera to rural and depopulated areas (led by Irish National Opera in Ireland).

The remainder of the paper is structured as follows. First, we present the related work for collaborative art approaches based on previous experiences from the artistic partners of the TRACTION consortium and from other stakeholders. Second, we describe the toolset that will be developed within TRACTION, which will provide: a) a Media Vault for content storage and asynchronous communication, b) a Performance Engine for stage orchestration and synchronous communication, and c) an Immersive Media Environment for creation and rendering (and distribution) of interactive and immersive experiences. Finally, we present the conclusions and the next steps.

II. Related Works

In the following, the most representative recent initiatives for a future, more inclusive and open, opera form are summarised, highlighting the key contributions to the state-of-the-art.

Los Angeles Opera [2]. LA Opera is an example of sharing the arts as something essential to building communities and as part of their civic responsibility. LA Opera supports educators, helping to knit opera in the classroom. Not only do they guarantee that everyone has access to the opera, they give the opportunity to participate in the creation process. LA Opera deepens the community's experience with this art form through several broad initiatives. During the last 11 seasons, LA Opera has worked with the Cathedral of the Virgin of Angels in downtown Los Angeles to present free performances to the community, including Noah Floods, Judas Maccabaeus and The Festival Play. These community opera shows include community singers, actors and orchestra members, acting alongside LA Opera singers and orchestra.

Royal Opera House [3]. All Together Opera was a three-year program run by the Royal Opera House for adults over 65 living in Camden and Westminster to participate in singing and opera and promoting welfare. The program focused on active participation in the community and support for elderly people to enjoy and experience the opera. Professional singers with experience working in community settings partnered with sheltered homes and dining room by offering singing sessions at Westminster and Camden community sites or at the Royal Opera House. Practices to create a company of All Together Opera were also regularly performed at the local level.

The Calouste Gulbenkian Foundation [4]. The Monster in the Maze is a community opera project where professionals, amateurs, adults and children united to act on the stage in Lisbon. Based on Jonathan Dove's opera on the legend of Theseus and the Minotaur, this multimedia production of Eve Signeyrole premiered at the Aix-en-Provence Festival in 2017. The opera was designed to be sung together by professionals and amateurs, sharing a stage with groups of adults and children from different parts of the country. Celebrated by critics as “marvellous and enchanting”, it was a great show for all ages that also looked poignantly at the present times, especially regarding social dramas, changes and movements.

Birmingham Opera Company [5] has a willingness to reflect the city of Birmingham, with its audiences, artists and stories. Innovative work constantly attracts new and changing audiences. Each year the team absorbs part of the world's most exciting artists in Birmingham and trains hundreds of volunteer participants to create a large-scale show in an extraordinary space. It combines singers and professional musicians with community actors, and in doing so, it relates to a much more diverse audience, with a closer art form. They perform operas in stores, shopping centres, train stations - even in an ice rink. The public moves with the action. A unique fusion of international artists and local artists who offer artistic and social changes. Project that works throughout the year offering more than 50 workshops and performances throughout Birmingham to introduce people to opera. During these sessions, the participation of those who have never been in an opera as singers and performers is encouraged. The latest production (Lady Macbeth of Mtsensk) involved professionals and a diverse community group including asylum seekers. The company’s sold out performances were hailed by The Times as ‘a triumph that’s exceptional even by its unique standards’ (11 March 2019).

Welsh National Opera Youth Opera [6]. The Youth Opera is an award-winning training program for anyone who loves singing. You do not have to have experience, but enthusiasm, commitment and willingness to work with other young people.

There are no auditions for younger groups, and they participate in an annual showcase, having access to regular opportunities and assisting in WNO trials and shows.

Setubal Music Festival [7]. Known musicians joined professional and amateur bands to offer the Setubal Music Festival 2018, with events in various places in the region, for the most diverse audiences. Artists and trainers with national and international recognition such as Maria João, Celina da Piedade, João Gil, Ariane Merit and Ricercare Cor participated in programs with the local community, including amateur groups and people with special needs, within the inclusive spirit of the event. The festival emphasized songwriting and several hundred young people shared the experience of composing, writing and performing their own songs in a range of styles that reflects the city's rich cultural diversity.

Garsington Opera [8]. The first communal opera of Garsington Opera, Road Rage, took place in 2013 and had more than 180 people on stage, ranging from schoolchildren to the elderly, from the local community that worked with singers, musicians, directors, designers, choreographers and professional and technical scene directors. A new commission by Richard Stilgoe and Orlando Gough involved people from surrounding communities, aged 5-85, who participated as interpreters or as members of the production team. More than 2,400 people benefited directly from the Community Opera and many more from the next three-year training program. Ingenious and fast-paced music matches the text and involves all aspects of the community's cast.

Streetwise Opera [9] has been making opera with homeless people in Britain for nearly 20 years, demonstrating that this art form can include non-professional singers and retain its innovative edge. Their productions platform the skills of their performers in a professional arena, showing that whatever life throws at them, they can achieve great things. Their workshop programme offers a dependable source of creativity in lives where everything else can be changing. Their work reflects the life experience and vulnerability of members, a high proportion of whom are also disabled and have mental health conditions. Streetwise Opera has done that for classical works such as Bach's St Matthew Passion as well as in new, satirical and political creations by young composers.

As these examples show, performing arts companies have been exploring new approaches to community participation for some years. The most committed, such as National Theatre Wales or Streetwise Opera, have brought the community permanently into their organisations, but this is currently the exception. Most initiatives are still relatively small-scale, and they are not common in major cultural institutions. In opera, they have tended to focus on inclusion into the existing form, especially in the participation of non-professionals in choral singing, as in the examples from Birmingham Opera and the Royal Opera House. Initiatives have tended to develop in parallel to main house productions, as one-off projects that do not address the underlying obstacles to cultural inclusion or bring a lasting change in the relationship between communities and opera producers.

TRACTION is innovating by taking the idea of co-creation into opera production at a scale that has rarely, if ever, been tried and developing a principled, replicable and people-centred methodology to guide the work. The partnership of three different opera and music organisations, and the very different contexts in which they work, will assist with the identification of core strategies that are artistically effective and capable of winning the trust and enthusiasm of marginalised people. The partners are committed to achieving lasting change in their relationship with marginalised citizens, not by 'solving' a problem but by developing forms of dialogue that lead to people being involved in all aspects of the work of opera creation. TRACTION is not a community outreach project. It is an attempt to redefine the relationship between the opera and classical music producers and the most marginalised in the community. It is also innovative in bringing together three very different context - the multicultural city, depopulated rural areas and closed institutions – to identify the essential components of successful co-creation. This will help ensure that the outcomes of the work are genuinely replicable by other organisations in different situations.

III. THE TRACTION TOOLSET

Based on an analysis of the objectives and use cases of the trials of the project, TRACTION has identified three main toolsets, with the following initial requirements.

A. Media Vault

The Media Vault is a software component that allows for the storage of a heterogeneous group of media objects (2D and 360 videos, volumetric media). It enables asynchronous communication between users around the uploaded content, for conversation and co-creation, and includes functionality for generating stories based on the stored content. The media vault has a strong requirement on accessibility at the user interface, for supporting its use by people with cognitive and sensory disabilities. Figure 1 shows a sketch of the Media Vault.

Regarding the requirements for the Media Vault, first and foremost, it demands some form of online storage to store all assets which are required for the application to function. These assets include, but are not limited to, graphics, icons, markup, script and style files as well as content uploaded by users, such as video. For these videos, we may want to store originals as well as transcoded versions in different resolutions and bitrates. This online storage should function and be organised like a file system, with the ability to group assets into a hierarchical structure. While the end-user (by way of a web interface) should be able to read from this storage, they should not directly be allowed to write or modify it. Write access should be strictly limited to components which take user input and process/validate the given inputs before writing it to the storage. At the same time, access to this storage system should be shared among all components/processes with write access.

In order to facilitate fast and convenient access to static assets located in the online storage system, a content distribution system of some description would be advantageous. Such a system enables caching and distribution of files over a larger

geographical area at edge locations to ensure data is always available in closest-possible proximity to end-users. Caching of the data also minimises direct reads at the file storage system, thereby reducing cost.

Figure 1: Sketch diagram of the Media Vault

Further, as a point of interaction between end-users and the system, some form of compute engine, such as a cloud-based VPS (virtual private server) is required. This machine renders the web user interface with which the user interacts and performs the necessary processing and database queries. It will also submit long-running jobs to other processes in the system, such as video transcoding, through a common messaging bus. This compute engine should be set up in such a way that it can be seamlessly and flexibly duplicated in times of high load. This can either be achieved by multiplexing several instances behind a load balancer or spawning additional threads or processes within a single engine. Besides running a user interface, this engine can also be employed to serve an API (application programming interface), which makes the data accessible computationally. This approach could facilitate the development of mobile and/or desktop applications which interact with the infrastructure.

As mentioned in the previous paragraph, long-running operations such as video transcoding should be offloaded to secondary services in order to guarantee maximum responsiveness of the web interface. Such a service will pick user-uploaded video files up from the file storage, process them and store the results back into the storage. It should be flexible enough to handle different input and output formats transparently and signal errors in a standardised way.

For storing user-generated content, structured data and asset metadata a hierarchical file storage is certainly not optimal. In this case, a structured database should be employed. This database can either come in the shape of a relational or document-oriented database. Both solutions allow for storage and efficient retrieval of data in a structured way. The database can be queried to transform and aggregate the data and retrieve analytics and insights. Furthermore, the database should store user profiles and access control rights. This database can be accessible through all services running on the system although it is not required. At the very least, though, it should be accessible to the compute engine running the web interface

Finally, to tie all services together and give them a convenient way to communicate, a message bus is required. This is yet another service running within the system. Processes can subscribe to message channels for events they are interested in, as well as publish messages to channels to instruct other processes to perform work. So, for instance, if a user uploads a video through the web interface, the compute process will submit a message to a dedicated channel for transcoding operations. A transcoding process listening on that channel will pick up the metadata and perform the transcoding task. Once complete, it will publish another message on a channel informing service of success or failure. In this example, a process that might be interested in such a message might be the web interface (which would then update a database entry) or a machine learning module, which could perform further analysis on the converted video.

As a summary, a working media vault should provide the following core components:

1. Web services module: Apache server as a single access point for client-server applicative communication. This module should be deployed on front-end servers, with traffic distributed by load balancing equipment;
2. Batch jobs module: Scalable middleware entities deployed on back-end server/s. Central orchestration of atomic batch services such as media import, media info extraction, transcoding, server notification and others. This module should be deployed on a backend server.
3. Transcoding module: This module manages all media transcoding tasks, by utilizing open source and/or commercial transcoders. This is a CPU intensive module and could either be deployed on a backend server at a local deployment or can be distributed using independent transcoding servers deployed in a cloud solution.
4. Shared storage: A dedicated disk space that is shared and accessible by every server within a specific deployment. The Shared storage holds all content and application files, including media assets, widgets or applications, skins, thumbnails, players/playlist configuration files (UI conf) etc. The shared storage can be deployed as part of a local deployment or using independent storage within a cloud solution.
5. Operational database: This is the applicative database, used for storing and managing both content related data (metadata, identifiers, URLs etc.) as well as application and business logic supporting data. The operational database should be deployed as part of a local deployment, preferably on dedicated servers utilizing a master/slave topology.

6. Site admin console: This module is responsible for operating the Admin Console, enabling site administrators to monitor and operate their own deployment of the online video platform.
7. Video analytics module: This module is responsible for running advanced analytics on the uploaded content. For example, this module is responsible for extracting audio transcriptions, adding subtitles and creating automatic video summaries.

B. Performance Engine

The Performance Engine is a communication infrastructure, deployed at the theatre or in the rehearsal rooms. It enriches the live performance by orchestrating in real-time the stage. It allows for remote participants to see the show and to directly contribute to it. This communication infrastructure does not only enrich the show, but enables as well synchronous communication between actors and spectators.

Figure 2: Sketch diagram of the Performance Engine

For orchestrating the performance in real-time, several roles are needed. There must be at least an administrator, responsible for the whole performance, using one or more devices depending on the complexity of the application and the number of services to be managed. Another important role is that of the operators, who are responsible for managing which content is visualized on different displays. Each operator is typically in charge of multiple devices at the same time. The final role is the one represented by end-users. This all-encompassing role represents everything that is neither an administrator nor an operator: all the displays in the stage (or the fully digital representation), the audience providing additional information through their mobile phones, producers who want or plan to add content during the performance or even remote audience who, while watching the performance through a TV, laptop or mobile phone can send feedback and content through their smart devices.

In terms, of functionality, the engine is required to support several multimedia formats: first and foremost, it should be able to fetch and play the videos and images uploaded by the users to the media vault, as it will also act as a database for User Generated Content (UGC). Apart from this data, the engine must handle real time data, as it will be in charge of streaming real time videos from professional cameras in the stage as well as videos created by the on-site and remote audience. The engine should support static and animated images, textual information, illustrations, presentations as well as UGC like social media posts and reactions. Finally, the engine should ideally handle advance multimedia information such as 360 or volumetric videos and manage how this type of content is handled on devices with reduced processing capabilities.

Furthermore, the engine should be developed with the possibility to easily support other current or future data types: different scenarios would have different requirements, and new standards for audiovisual content appear every few years. That is why extensibility and flexibility are parts of the Performance Engine requirements.

To ensure multimedia synchronization, requirements include support for WebSocket to provide clients communication. A server providing a master clock (based on *TimingService* or similar libraries), calibrated to the multimedia playback rate, is also required. Furthermore, the engine should also be able to operate, when requested, in an unsynchronized scenario, where all video and audio content is sent and played on a best-effort mode with the aim to keep latency to a minimum.

C. Immersive Media Environment

The Immersive Media Environment includes both the authoring tools, for creating, and the rendering engines, for deploying, immersive and interactive experiences in the form of capsules or radically new Opera productions. This environment will enable static (dome-based) and moveable (HMD based) installations, pushing the boundaries of immersive media consumption. It will as well enable browser-based remote experiences, through the integration of the WebXR standard.

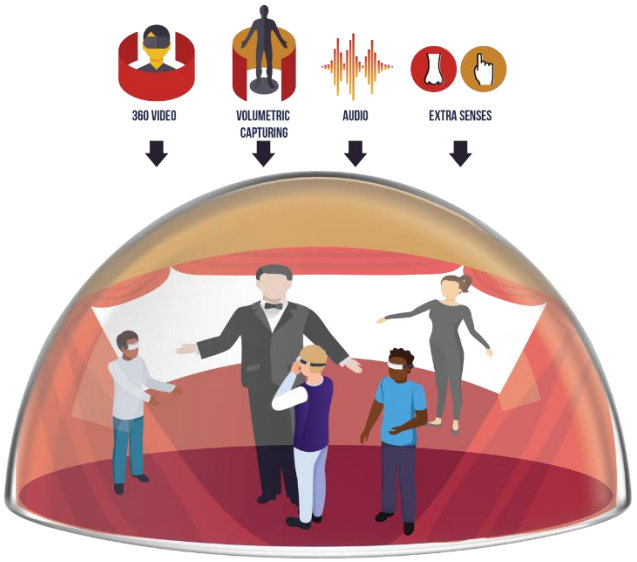

Figure 3: Sketch diagram of the Immersive Media Environment

The authoring and rendering of immersive media require capabilities that allow import of multi-media assets, spatial and temporal arrangement and interconnection of these assets into a completed immersive experience, interactions with the experience through interfaces and peripheral controls (UX/UI) and finally exporting the entire experience to an enabling platform for consumption.

The engine for authoring and rendering immersive content must support importing and manipulating multiple files and assets, such as 3D models and textures, volumetric videos and photos, photogrammetric and mesh-based depth information of objects and locations, audio in various formats (mono, stereo, ambisonic, etc.), 360-degree video (monoscopic and stereoscopic), 360-degree photos and standard "2D" videos and photos.

Spatial and temporal arrangement/interconnections must allow creators to arrange all assets in a non-linear manner within a spatial virtual environment. Assets may be passive or interactive and may need to be controlled or guided by the user through the use of digital or physical interfaces, such as gaze control, motion control, computer peripherals, voice and hand recognition.

Gaze control affects computer actions by changing the direction of one's gaze. This involves determining the angle or position of a user's visual attention, usually with cameras, and choosing from a set of available instructions that are mapped to those positions.

Motion controller is a type of game controller that uses accelerometers or other sensors to track motion and provide input, this can generally be 3DOF or 6DOF. Other standard peripherals or HID (human interface devices) such as keyboard, mouse, joystick and touch screens should also be supported, as they are the most traditional input methods.

Voice recognition, in particular for simple commands, has advanced rapidly in recent years, as well as hand recognition and tracking features, which enable the use of hands as an input method on devices. It delivers a sense of presence, enhances social engagement, and delivers more natural interactions with fully tracked hands and articulated fingers.

Immersive experiences must be exportable from authoring tools to enable unified VR experiences to take place. We can extend or use the capabilities of Unity Cloud services to enable this for TRACTION.

The main technologies suitable to author/build projects for immersive platforms include Unity, Unreal Engine, WebXR and Mozilla Hubs. The applications created in these engines must support the inclusion of assets generated in other platforms, such as 3D models and audio. That will result in the final immersive experiences to be delivered to users.

Therefore, the immersive media engine must have important features for immersive content authoring, such as build, compilation and versioning capabilities, support to numerous file types to be imported into the immersive application, support to multiple input devices and hardware, and export features for multiple operating systems and devices.

Assets and applications must be stored on a repository with all authors' creations, including 3D models, videos and audio. The repository must also contain the compiled applications for download.

The immersive engine server must also contain file management capabilities and a control centre for servers monitoring, video and audio transcoding tools, and user management features, as multiple authors from different trials must have access to specific files/folders.

User devices such as desktops, smartphones, tablets and VR headsets must be able to support the immersive content created in TRACTION. These devices must be able to install the applications, which have minimum requirements on operating systems, storage, memory, graphics APIs and CPU. Audio support and compatible web browsers are also required.

Web-based players can be used for streaming of 2D and 360° content. The player must have accessible features, such as subtitles, audio description, sign language videos, as well as support to adaptive standards (e.g. MPEG-DASH) for content adaptation. Adaptation also requires that transcoding technologies must be implemented into the storage and servers, for automatic encoding of video into multiple resolutions.

IV. Conclusions and Next Steps

In this article we present a first iteration of the technical toolset that the TRACTION project is going to provide and it is already developing. The project will improve and extend these technical requirements, technological toolsets and the architectural decisions during the following iterations until the end of the project (December 2022).

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