

Capturing the Intangible

An Introduction to the I-Treasures Project

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Abstract: Cultural expression is not limited to architecture, monuments or collections of artifacts. It also includes fragile intangible live expressions, which involve knowledge and skills such as music, dance, singing, theatre, human skills and craftsmanship. These manifestations of human intelligence and creativeness constitute our Intangible Cultural Heritage (ICH), a basic factor of local cultural identity and a guaranty for sustainable development. In this paper, we briefly introduce the i-Treasures research project, which aims at developing an open and extendable platform to provide access to ICH resources, enable knowledge exchange and contribute to the transmission of rare know-how. The project goes beyond digitization of cultural content; it creates new knowledge that has never been analysed or studied before through novel methodologies for the analysis and modelling of ICH based on multisensory technology. High-level semantics are extracted enabling researchers to identify possible implicit or hidden correlations between different ICH expressions or interpretation styles and study the evolution of a specific ICH. Four different ICH cases are studied: traditional songs, dance interactions, pottery and contemporary music composition. Combining conventional learning procedures and sensorimotor learning through an interactive 3D environment, i-Treasures breaks new ground in education and knowledge transfer of ICH.

1 INTRODUCTION

Cultural expression is not limited to architecture, monuments or collections of artifacts. It also includes fragile intangible expressions and is controlled by the intelligence of the human creativeness, which involves practices, representations, knowledge and skills. Such expressions include music, dance, singing, theatre,

human skills and craftsmanship. The importance of this intangible expression is not limited to cultural manifestations but it coexists with the wealth of knowledge, which is transmitted through it from one generation to the next.

This transmission of knowledge has both economic and social value since it goes further and far beyond cultural fragments and attitudes. This kind of culture is called Intangible Cultural Heritage

(ICH). ICH is “constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity” (UNESCO, 2003). ICH is at the same time traditional, contemporary and living, because it does not only refer to inherited knowledge but also to contemporary, rural or urban, cultural expressions. In other words, it refers to the past, to the present, and, certainly to the future. It is the “mainspring of humanity's cultural diversity” and its maintenance is a guarantee for continuing creativity. For this reason, UNESCO introduced the term “Living Human Treasures” (LHT) for persons who possess to a high degree the knowledge and skills required for performing or re-creating specific elements of the intangible cultural heritage.

ICH's creations are transmitted orally or by gestures and are modified over a period of time through a process of collective recreation. As the world becomes more interconnected, many different cultures come into contact and communities start losing important elements of their ICH, while the new generation finds it more difficult to maintain the connection with the cultural heritage treasured by their elders. Museums can play the role of a mediator or communication bridge to fill the gaps between generations and to share the community knowledge on a larger scale, however, their role is usually limited to presentation, while ICH is more efficiently preserved 'with' the people or community by protecting the processes that allow traditions and shared knowledge. To this end, ICT technologies can contribute to the safeguarding of ICH, improve its presentation, provide seamless and universal access to cultural resources, and support services for research and education.

The main objective of the i-Treasures project is to conduct multidisciplinary research relying on the development of both novel methodologies and new technological paradigms for capturing and analyzing different forms of ICH, either traditional or contemporary, and propose a novel strategic framework for the safeguarding and transmission of ICH. This novel methodology is based on the use of multisensory technology for the generation of cultural information that has never been analyzed before and not for the digitalization of existing cultural content. The project focuses on the study of ICH domains for which human body motion is extremely important, i.e. performing arts and traditional handicraft. Its basic goal is scientific research and technological development for the

analysis, modeling, recognition, renewal and transmission of both contemporary and traditional cultural knowhow. Four specific ICH cases will be studied in detail: a) rare traditional songs, b) rare dance interactions, c) traditional craftsmanship and d) contemporary music composition.

The contribution of the i-Treasures project to the generation of novel data related to ICH is just the starting point of this research effort. The main objective concerns the semantic analysis and the presentation of the content in order to build a platform for knowledge exchange between researchers and for the transmission of rare know-how from LHTs to new apprentices. To this end, high-level semantics are extracted enabling researchers to identify possible implicit or hidden patterns and correlations between different ICH expressions (e.g. between “Cantu in Paghjella” and “Canto a Tenore” singing traditions) or different interpretation styles of the same ICH (e.g. the Patriarchal and the Mount Athos interpretation styles in Byzantine music). The unveiling of such hidden correlations is expected to help the scientific community study the evolution of a specific ICH through its transmission from generation to generation or to other communities. Besides the use of conventional learning procedures, the adoption of sensorimotor learning methods can change radically the way that rare know-how is transmitted from one generation to the next.

2 ICH PRESERVATION AND TRANSMISSION

ICH's creations are transmitted orally or by gestures and are modified over a period of time through a process of collective recreation. To this end, there is always a risk that certain elements of ICH could die out or disappear. The issue of the preservation of intangible cultural heritage came to light as the effects of globalization caused the diminishment of the unique culture of many communities. As the world becomes more interconnected, many different cultures come into contact and communities start losing important elements of their ICH, while the new generation finds it more and more difficult to maintain the connection with the cultural heritage treasured by their elders.

For example, a Corsican singing tradition, namely the “Cantu in Paghjella”, has been listed by UNESCO as one of ICH treasures in need of urgent safeguarding. Paghjella makes substantial use of echo ornamentations and it is sung a capella in a

variety of languages including Corsican and Sardinian, Latin and Greek. Comment: the Paghjella is emitted only using Corsican and Latin languages. Despite the efforts of its practitioners to revitalize its repertoires, Paghjella has gradually diminished in vitality due to a sharp decline in intergenerational transmission caused by the emigration of the younger generation and the consequent impoverishment of its repertoire. A similar case is the “Canto a Tenore” in Sardinia, which was inscribed by UNESCO in 2008 on the representative list of the Intangible Cultural Heritage of Humanity. Another example is the byzantine music, which is the music of the Byzantine Empire composed to Greek texts as ceremonial, festival, or church music. Research done in this field has proved that byzantine music has its root in ancient Greek music and although it has not been listed by UNESCO as an endangered ICH, there is a risk that certain interpretation styles of Byzantine Hymns could die out if no action is taken.

There are numerous examples of living ICH expressions both at European and international level, such as the art of pottery, which has played a significant role in many societies since ancient times; local traditional dances, e.g. the Romanian Căluș ritual dance, which also formed part of the cultural heritage of the Vlachs of Bulgaria and Serbia (inscribed in 2008 on the Representative List of the Intangible Cultural Heritage of Humanity) or the Mongolian folk dance Biyelgee, which is typical in remote areas of western Mongolia and has been inscribed by UNESCO in the list of ICH in need of urgent safeguarding; and so many other intangible treasures, which have either been listed by UNESCO or recognized by local communities and groups as part of their living tradition and heritage.

In recent years, ICH has received international recognition and its safeguarding has become one of the priorities of international cooperation thanks to UNESCO's leading role. The Convention of the Safeguarding of Intangible Cultural Heritage of UNESCO (UNESCO, 2003) sets the intangible cultural sources as a basic factor for the local cultural identity and constitutes an eternal guaranty for sustainable development. ICH is manifested inter alia in the following domains: (a) oral traditions and expressions, (b) performing arts, (c) social practices, rituals and festive events, (d) knowledge and practices concerning nature and the universe, and (e) traditional handicrafts. Within this framework, many museums have already started exploring new ways for safeguarding ICH.

Museums can play the role of a mediator or

communication bridge to fill the gaps between generations and to share the community knowledge on a larger scale with different communities and a diverse range of visitors. However, there are specific limitations to their role: a) usually the physical presence (especially in the case of small local museums) of visitors is required, b) in many cases, national museums focus on the presentation of the local ICH, c) museums usually collect, preserve and interpret material evidences associated with the past, while ICH is not simply about the past, but also about the present or even the future and can be used as the base for new cultural expressions, d) the presentation and interpretation in museums is static, while the elements of ICH are living (Yin, 2006). Moreover, ICH is more efficiently preserved 'with' the people or community by protecting the processes that allow traditions and shared knowledge, while museums are usually limited to presenting ICH treasures. For this reason, modern ICT technologies can be employed to improve the presentation of ICH, raise public awareness, provide seamless and universal access to cultural resources, support services for research and education and bring hidden intangible treasures to light. Especially the latter constitutes the most challenging issue in the safeguarding of ICH and can:

- a. give rise to a deeper understanding of this kind of cultural heritage,
- b. unveil unknown correlations between ICH treasures associated with societies from different time periods or geographical areas,
- c. create new ways for cultural expression that connect the past and have relevance in the contemporary world, and
- d. break new ground in education, knowledge transfer and research of ICH.

3 PROPOSED METHODOLOGY

The i-Treasures overall goal is to develop an open and extendable platform to provide access to intangible cultural heritage resources for research and education. The core of the system lies in the identification of specific media patterns (e.g. postures, gestures, audio patterns, actions etc.) using multi-sensor technology (e.g. 2D/3D optical sensors, ultrasound sensors, microphones, EEG etc.) in order to reveal hidden intangible treasures from different ICH forms. In these ICH forms, the human body motion is a dominant factor, however a specific sensors set up is defined for each use case, as

described in Section 3, taking special care to use non-obtrusive technology, which does not affect the performance of experts; however, especially in the case of rare songs, the use of special equipment (e.g. ultra sound sensor) for the modelling of vocal tract is inevitable.

In order to successfully fulfil the aforementioned goals, the establishment of an active group of LHT is required. In a typical application scenario, the exemplary bearers of ICH performing their art are captured using multimodal sensors. Image/signal processing and pattern recognition techniques are applied to recorded signals to extract low (e.g. motion tracking) and medium (media patterns, e.g. postures, actions, audio tempos etc.) level features.

Subsequently, data fusion analysis is applied to exploit information across different modalities, while context and content are integrated for mapping the set of low or medium-level multimedia features to high-level concepts using probabilistic inference, i.e. transforming the extracted data into a level of interpretation that is understandable by humans. Given that digital heritage resources include heritage artifacts in digitized form, the semantic analysis of multimedia content, taking into account the specifications defined in ESE (Europeana Semantic Elements) (Europeana, 2013), (Concordia, 2009) is necessary since the automatic annotation of such artifacts enables their quick integration in digital collections and facilitates various research or educational tasks.

This completely novel information coupled with other cultural resources is accessible through the i-Treasures platform in order to enable the widest possible participation of communities, groups and individuals in the safeguarding of ICH. The platform gives access to different types of content (e.g. text, audio, images, video, 3D graphics) from different types of heritage or educational institutions. Using the proposed technology, the cultural institutions are capable to decide what content they will produce, thereby contributing to the enrichment of the cultural content. The platform is an open-source content management system offering a variety of advantages (automated templates allowing multi-lingual and universal access to the content, scalable expansion, easily editable content, access and version control, scalable feature sets with installable software plugins or modules to extend functionality, etc.). For this reason, as depicted in Figure 1, the web platform consists of four different sub-systems for i) user interaction (browsing, searching, viewing, playing), ii) back-end management of the web platform (user management, template management, etc.), iii)

database management and iv) educational management of the ICH treasures. The main focus of interest on the central database of the platform is the metadata repository and the corresponding knowledgebase (instantiated ontologies) that hosts the products of the semantic analysis.

In addition to the aforementioned functionalities, 3D technology taking advantage of recent advances in web-based game engines is used to develop a learning environment, either as a standalone application invoked by relevant interface handles, or as an embedded into the platform application, which will enhance training and evaluation of the learner's performance by means of sensorimotor learning. The application enables users to create an avatar, i.e. a 3D representation of them that visualizes their motions using multimodal inputs from different sensors. An AI based virtual tutor (Figure 2) corrects/ manipulates/guides the user to help in mastering the ICH by providing visual and audio feedback. The application compares user inputs with the master inputs in the database and evaluates the performance of the user.

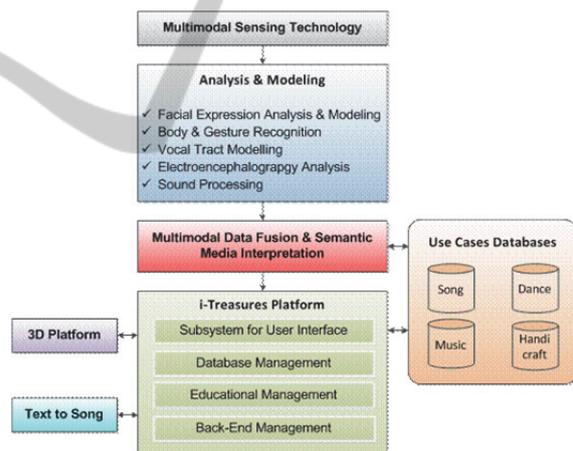


Figure 1: Proposed methodology.

Animation of vocal tract gestures, which can significantly contribute to the improvement of learners' performance (in singing), is also supported. Another novel feature is the text to singing voice service of the platform, which is able to produce personalized singing voices on the fly for the uses cases of Byzantine, Corsican and Sardinian music. The educational aspect of the platform is technically realized by a seamlessly interoperable Learning Management System (LMS) for planning, implementing and assessing learning processes in order to support educational scenarios providing personalized adaptive learning. The learning

scenarios encompass and distinguish among formal, non-formal and informal learning.

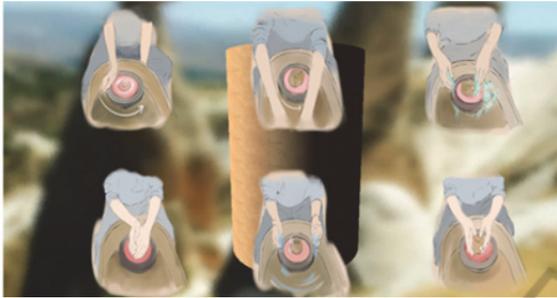


Figure 2: Virtual tutor instructions for the use case of pottery.

4 USE CASES

Four different ICH cases are studied within i-Treasures: a) rare traditional songs, b) rare dance interactions, c) traditional craftsmanship and d) contemporary music composition.

4.1 Rare Singing Knowledge

The singing use case deals with four different singing techniques. The “Cantu in Paghjella” of Corsica (France) and the “Canto a Tenore” pastoral songs from Sardinia (Italy), which both have been listed by UNESCO to the Inventory of Intangible Cultural Heritage in need of urgent safeguarding, the Byzantine hymns from Mount Athos as well as the “Human beat box” (a newly expanding contemporary singing style, where the vocalist imitates percussive and other instrument sounds like trumpet or guitar). Revealing hidden treasures for the aforementioned cases is expected to contribute to improved techniques for teaching singing and will make rare singing styles accessible to a wider public.

Our goal for this case study is the development of innovative methodologies for multimodal voice and gesture analysis based on state-of-the-art sensors and data fusion techniques. The development of a light mobile hyper-helmet (Figure 3) with light instruments (a novel ultrasound miniaturised transducer, an optical camera, a piezoelectric transducer and/or nasal acoustic microphone will be mounted) for field recordings is one of the major objectives of the project, which will enable us to produce knowledge about the investigated singing styles and the capacities of the human voice apparatus.

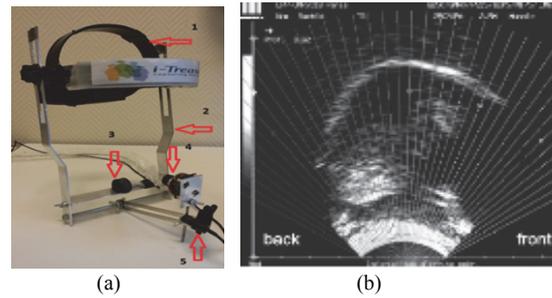


Figure 3: (a) The proposed hyperhelmet (1.Adjustable headband, 2. Probe's height adjustment strut, 3. Swivelling probe platform, 4. Lip Camera Proximity Adjustor, 5. Microphone) and b) ultrasound image showing tongue position.

Voice, speech and singing are produced at the level of the vocal tract and the oro-facial region, associated and dependant on aerodynamic energy. Vocal tract sensing is of major importance to relate specific artistic vocal productions to specific configurations and movements of the vocal apparatus. Recent studies revealed a close relationship between external body gestures and internal vocal gestures in beat boxers during their vocal performances (De Torcy et al, 2010). In addition, acoustic-phonetic and linguistic analysis (languages spoken, rhythm, prosody etc.) can complement the collection of instrumental analyses. Apart from the hyper-helmet, slightly more invasive measurements will be carried out for on-site recordings, based on fiber-optic laryngeal sensors (for the larynx and gestures of the surrounding organs), and EVA (Evaluation Vocale Assistée) for intra-oral pressure and flow measurements.

Examples of features that can be extracted for this use case are tempo, rhythm, prosody, body and hand gestures, singing style, changes of the vocal tract, etc.

4.2 Rare Dancing Knowledge

The dance case-study focuses on two specific use cases: contemporary dance and traditional dance. Dance is an immaterial art by essence, as it consists in the motion of the performer's body. Dance can convey different messages according to the context, and focus on aesthetics or artistic aspects (contemporary dance, ballet dance), the cultural and social aspects (folk dances, traditional dances), a story telling (symbolic dances), spiritual meanings (whirling dervishes), etc. According to the type of dance, the precision of the motion and the way it is executed (referred to as “motion quality”) is of uppermost importance (contemporary dance), or is

secondary as only the functional motion will matter (most traditional dances). Some dances also come with additional accessories like costumes or instruments, which are part of the performance and need to be taken into account as they modify and influence the body motions.



Figure 4: Contemporary dance capture using an optical motion capture system.

Depending on the degree of precision of the motion that has to be taken into account and to the constraints posed, different type of sensors are used:

- i) Optical motion capture, which is the most accurate motion capture technique, but it is also the most expensive and constraining one. The capture area is surrounded by cameras and reflective markers are taped to the performer's body. These markers are tracked by the cameras and their position in the 3D space can be known on the sub-millimeter precision.
- ii) Inertial motion capture: inertial sensors attached to the limbs can track the angles between the body segments. This mocap system is less accurate than optical mocap but it is very stable and does not need cameras or specific lighting conditions around the mocap area. Furthermore, as it is not linked to vision, it is the only system that will be able to capture the leg motion under a skirt.

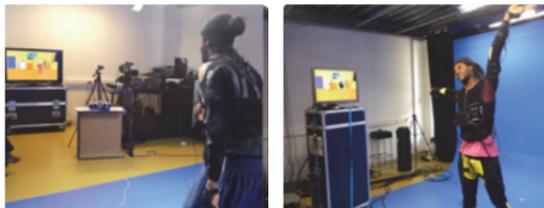


Figure 5: Contemporary dance capture using inertial sensors.

- iii) Depth cameras such as Microsoft Kinect sensors can track the volume of a performer and produce skeletal data. This system is very cheap but the data captured are still noisy and some rotations or body parts cannot be recorded (especially when two dancers interact).

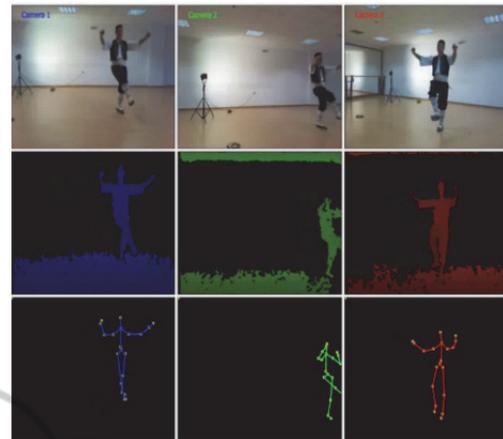


Figure 6: Traditional dance capture using multiple synchronized Kinect sensors.

Features that will be extracted for this use case include motion quality, dance figures, type of dance, dancer style, etc.

4.3 Traditional Craftsmanship

The case study of the traditional handicrafts aims at the analysis, modelling, recognition and semantic analysis of gestural interactions between the craftsman and his material. Within the proposed context, handicraft interaction means gesture control of the material. In order to develop a hybrid gesture recognition methodology, depth cameras are used for the detection of global hand gestures and postures, optical cameras for finger gesture recognition and embedded sensors for the measurement of gestural parameters (Figure 7).

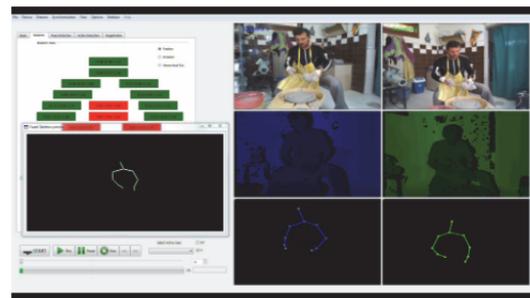


Figure 7: Capturing of a pottery artist using multiple synchronized Kinect sensors.

Some examples of features that will be extracted from this use case are finger trajectories, hand movements, basic phases of wheel-throwing pottery (hollowing, pulling, thinning), etc.

Thus, this novel methodology integrates both gestures performed in space, implying motion of the

arms, and hand gestures performed on a surface or on objects, taking into account the fingers' motions. The system continuously recognizes the entire gestural information of the craftsman, relying on the recording and the identification of the most effective interactions between him and his material. In short, this use case aims to "put in a closet" the most effective gestures of holders of rare handicraft knowledge.

4.4 Contemporary Music Composition

The performing arts combine both the communicational (expressions, emotions, etc.) and control aspects (triggering actions, controlling continuous parameters). The performer is both a trigger and transmitter connecting perception, gesture and knowledge. A few years ago, the electronic synthesizer was a revolutionary concept of a new music instrument that was capable of producing sounds by generating electrical signals of different frequencies by pianistic gestures performed on a keyboard. Nowadays, the music production still depends on musical instruments that are based on intermediate and obtrusive mechanism (piano keyboard, violin bow, etc.).

The case study of the contemporary music composition aims to develop a novel intangible musical instrument. This digital music instrument is a novel Multimodal Human-Machine Interface for the music composition where natural gestures performed in a real-world environment are mapped to music/voice segments taking into account the emotional status of the performer. A hybrid approach is used for gesture data acquisition and analysis based on 2D/3D and embedded sensors (Fig. 8), while the emotional status of the performer is analyzed via EEGs and facial expression analysis.

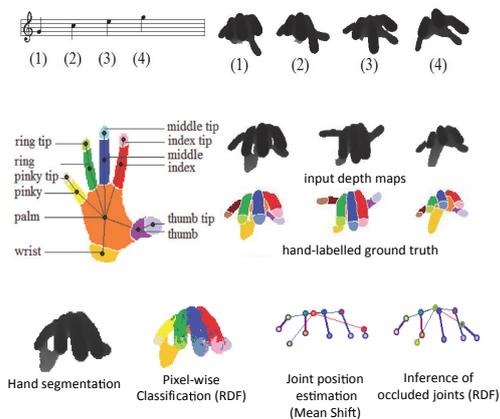


Figure 8: Hand skeletal model for depth images applied to capture music-like finger gestures (Dapogny et al., 2013).

All these gestures, expressions, emotions and sounds are integrated into the intangible instrument enabling users with different profiles (composers, performers, non-musicians etc.) to explore more sophisticated body/music interactions and control the synthesis of music entities. Those music entities can be a) music patterns of classic composers (i.e. Beethoven, Haydn or Mozart), b) natural and instrumental sounds or c) segments of speaking/singing voice.

This intangible musical instrument is not only addressed to experienced performers, musicians, researchers or composers, but also to users without any specific music knowledge. The heritage of the classic composers can this way be available to everyone; it can be better preserved and renewed using natural body and emotional interactions.



Figure 9: Interaction of the performer using EMOTIV for EEG/GYRO/AFFECTIVE recordings. The conductor is equipped with 3D Arduino accelerometers for gesture recordings and live electronics (Hadjileontiadis, 2011). Examples of features that will be extracted from this use case include natural gestures, facial expressions, emotions, musical patterns, music style etc.

5 CONCLUSIONS AND FUTURE WORK

The intangible cultural heritage represents an important part of the world heritage. However, since ICH is transmitted orally there is always a risk that certain elements of ICH could die out or disappear. Since the loss of such elements is irreversible, there is great significance in integrating the technological components required for the protection of ICH. Nowadays, UNESCO defines the transmission of rare ICH knowledge as a universal challenge. This challenge passes through three fundamental actions aiming at (a) the "learning" of this knowledge, (b) its "economical support" and (c) the "valorisation"

of the specific “cultural, social and/or public contribution“ of its holders. For many years, ethnologists have studied the characteristics (arts and techniques, oral traditions and living expressions) of groups and communities in their surroundings. Nevertheless, “learning” and “transmission” of rare knowledge has never been a privileged research field for the ethnologists, since these concepts still constitute separated headings for them. Thus, “what exactly” should be transmitted to next generations has never been defined, since it was extremely difficult to “capture it” (capture means analysis, study, recording, modeling and recognition).

The i-Treasures project provides a novel strategic framework for the safeguarding and transmission of ICH based on the development of both novel methodologies and new technological paradigms for capturing ICH. This novel strategic framework will give rise to the discovery of hidden intangible treasures and the generation of completely novel data related to ICH. This data coupled with other cultural resources will be accessible through the i-Treasures platform in order to enable the widest possible participation of communities, groups and individuals in the safeguarding, transmission and research of ICH.

More specifically, the i-Treasures project aims to develop a new technological approach that will:

- Contribute to the safeguarding of ICH: Multisensory technology (e.g. 2D/3D sensors, ultrasound sensors, microphones, EEG etc) will be used for the creation of cultural content that has never been extracted or analyzed before.
- Unveil unknown correlations: The analysis of such cultural content will allow researchers to discover unknown correlations between intangible treasures associated with different ICHs (e.g. between Corsican “Cantu in Paghjella” and Sardinian “Canto a Tenore” singing traditions).
- Give rise to a deeper understanding of specific forms of ICH: The discovery of hidden treasures is expected to help the scientific community study the evolution of specific forms of ICH through its transmission from generation to generation or to other communities (e.g. correlations between the Patriarchal and the Mount Athos interpretation styles of Byzantine music).
- Break new ground in education and knowledge transfer of ICH: Besides the use of conventional learning procedures, the adoption of

sensorimotor learning methods can change radically the way that rare know-how is transmitted from one generation to the next.

- Create new ways for cultural expressions: A novel intangible musical instrument will be developed within the i-Treasures project opening new ways for cultural expressions that connect the past and have relevance in the contemporary world.

Furthermore, since rare intangible cultural content and knowledge constitute local cultural resources, the project is expected to directly contribute to the development of a systemic methodology for the preservation, renewal and transmission of this knowledge to the next generations through the concept of prototype Territorial Schools. These schools could be created through combined actions based on the active participation of local agents (teachers, local cultural organisations, music academies, schools of History, etc.) acting as a means for stimulating creative economy and promoting local cultural tourism.

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