TASK: Introducing The Interactive Audience Sensor Kit

Florian Güldenpfennig
TU Wien
Vienna, Austria
flo@igw.tuwien.ac.at

Oliver Hödl
TU Wien
Vienna, Austria
oliver.hoedl@igw.tuwien.ac.at

Peter Reichl
University of Vienna
Vienna, Austria
peter.reichl@univie.ac.at

Christian Löw
University of Vienna
Vienna, Austria
christian.loew@univie.ac.at

Andreas Gartus
University of Vienna
Vienna, Austria
andreas.gartus@univie.ac.at

Matthew Pelowski
University of Vienna
Vienna, Austria
matthew.pelowski@univie.ac.at

TEI '16, February 14-17, 2016, Eindhoven, Netherlands
© 2016 ACM. ISBN 978-1-4503-3582-9/16/02…$15.00
DOI: http://dx.doi.org/10.1145/2839462.2856538.

Abstract
We introduce '*The interactive Audience Sensor Kit' (TASK)*. This modular system of wirelessly networked sensors facilitates the augmentation of artistic performances, in particular, music events or visual art. It was conceived to enable low-level and low-cost audience interaction by offering a set of tracker-nodes to be arranged across the venue as demanded by the corresponding performance event. In this paper, we present two modules from TASK, which are currently under development, and provide early insights from a field study. (1) TASKswitch reacts to the presence of bodies acting as an on/off switch and thereby can be used to modify particular aspects of a performance. (2) TASKvector, on the other hand, enables more complex input by tracking movement among the audience. For example, as we will show in the paper, we used the modules to create interactive audio-visual experiences for the audience where projections were modulated by TASK.

Author Keywords
Audience interaction; TASK; sensors; wireless; OSC; live performance; art; interactive art; music.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

Please note, we provide a demo video where TASKswitch, TASKvector, and the study location ("The Salome Experience") are briefly walked through in one minute (last accessed 23 Oct 2015):

https://youtu.be/f---ItiZBgI

Introduction and Related Work

Embedded systems for tangible and sensor-based interaction have become widely used in live performances, such as music or dance and installations of art [1, 2]. For example, for the contemporary opera "Death and the Powers", an entire set of custom performance technologies was invented and combined to realize the performance as intended by the composer [3]. This included robot characters, new musical instruments, spatialized multimedia systems, and other sophisticated technological components. While results of this event were promising, the development was rather costly. Another strand of contemporary artistic performances [5] and installations [6] incorporates spectators into the performance and thus generates immersive and interactive experiences for the audience by drawing on modern sensor technology.

Inspiring installations for audience participation and works like "Death and the Powers" motivated us to create a toolkit (TASK: The interactive Audience Sensor Kit) to support the technology aspect of similar projects. In particular, TASK was designed to support the augmentation of live performed musical/artistic events with audience interactivity. We aim at providing artists and creators with a modular system of wirelessly linked sensor-nodes that can be incorporated conveniently into installations to turn them into interactive live performances (see Figure 1). Hence, the goal of this work is to provide an affordable, versatile and stable solution for tracking audiences. It should enable interactive experiences also in projects, which are developed in the short term, feature smaller audiences, or which take place only a couple of times; in short, TASK seeks to bring interactivity to projects that cannot afford a lot of resources.

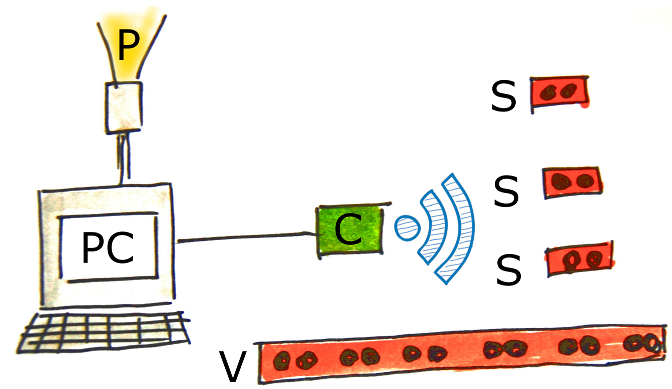

Figure 1: TASK - Interactive Audience Kit (components C, V, and S). In this illustration, a computer (PC) is connected to the coordinator module (C) via USB cable, which wirelessly communicates with three TASKswitch (S) and one TASKvector (V) sensor modules. In this figure, a projector (P) is also connected to the computer (PC), which is employed for rendering images used in a live performance. The projected images, again, are generated by an application also running on PC and receiving the data from S and V as OSC packages. As this is a standardized interface, the OSC packages can be read conveniently by other applications and can be used to different ends other than in this example.

Related to our approach, Rasamimanana et al. [4] created a set of modular sensor-based objects that were connected wirelessly to enable embodied music creation by using the modules together with everyday objects. In contrast to TASK, however, they aimed at creating individual instruments from everyday objects and not at tracking audiences. To the best of our knowledge, there is no project in the literature that seeks to accomplish this latter objective, and moreover, can enable this in a straightforward and easy to setup

Figure 2: Detail view of the prototyping process of the TASKswitch module.

Figure 3: Two TASKswitch modules mounted to one foldable chair using Velcro. As indicated by the arrows, the two sensor modules monitor the seating surface of the chair in order to wirelessly communicate to the coordinator module and computer, whether the seat is occupied by a person or not. The two circles show the positioning of the distance sensors, which were plugged into a box housing the microcontroller, power, and Xbee (visible in the left bottom corner of this figure).

fashion, both technically and physically (i.e., positioning the sensor across the venue).

In this work-in-progress paper we describe the concept of TASK, how it was implemented, and what our next steps in advancing it will be. Moreover, we report from an excellent opportunity, an interactive opera streaming-project named "The Salome Experience" where we had the chance to deploy one component of TASK (TASKswitch) in order to implement an interactive installation and to gather first experiences with TASK in the field with 'no strings attached'.

TASK: Interactive Audience Sensor Kit

The interactive Audience Kit (see Figure 1) consists of a variety of wirelessly connected sensor modules aimed at recording different types of user input by tracking (parts of) the body to be incorporated into live performances. By now we have created the prototypes for two different modules (TASKswitch and TASKvector) that we will introduce in the reminder of the paper. For the reader's understanding, we also provide a demo video where TASKswitch, TASKvector, and the study location ("The Salome Experience") are briefly walked through in one minute (https://youtu.be/f---ItiZBgI last accessed 23 Oct 2015). The main features of all TASK components are their modularity and their easy installation on-site, hence, making them an appropriate tool for field deployments. Together with its reliability/robustness TASK makes a versatile tool for augmenting performances. This versatility is also supported by its drawing on the OSC protocol (Open Sound Control [7]), which provides a widespread and established interface for application development, in particular, in the domain of electronic music and performances.

Technical Details

Technically, the backbone of all TASK modules consists of microcontroller-operated (in our implementation we used the Arduino platform) sensor(s) that are interconnected using XBEE radios. As these sensor modules are powered by a battery, they can be positioned freely within the reach of the XBEE radios (e.g., within a ceremonial hall as during "The Salome Experience") to wirelessly connect to the coordinator station, which again is connected to a computer. This coordinator station receives the readings of the sensor modules and transfers them via USB cable to an auxiliary computer application, where the readings are made available to external applications offering OSC packages as a standardized interface. In the example of Figure 1 and also in our first field trial (see below), this external application used the sensor readings as an input parameter for rendering images and projected them as part of an interactive live experience.

TASKswitch

TASKswitch (see Figure 1, S) depicts a simple, wireless 'switch' that can be incorporated easily as a 'one-dimensional' input parameter. For example, it can be used to detect whether a body is present or not (e.g., a person sitting on the seating area of a chair). Technically, we employed an infrared (IR) sensor housed inside a small box that could be attached with Velcro wherever needed (e.g., on a armrest). This small box housing the IR sensor was then plugged into a bigger box providing a microcontroller and connectivity. Altogether, smaller box and bigger box constitute the TASKswitch module (see also Figures 2-4).

Figure 4: Detail view of one of the four folding chairs as finally deployed during the field trial making use of one TASKswitch module per chair.

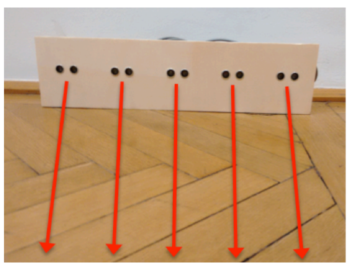

Figure 5: TASKvector module prototype (50 cm width). As indicated by the arrows, this wireless sensor module monitors the area in front of it (up to 300 cm in depth). When positioned alongside a wall TASKvector communicates the positions of obstacles (e.g., the feet of the people in the audience) to the coordinator module. The width of the module in this figure is 50cm, extendable to 250cm (under development).

TASKvector

While TASKswitch measured the presence of bodies etc. ('on/off'), TASKvector (see Figure 1 V and Figure 5) takes measurements at more complexity. In detail, TASKvector is a module to be placed on the ground alongside a wall and monitoring the surface in front of it in up to 300 cm depth. The prototype we developed so far spans a width of 50cm, and currently we are working on its expansion to up to 250cm. More precisely, we plan to offer individual modules that can be combined to up to five TASKvectors (=250cm total). Here, the challenge or restriction is that for cost reasons (hardware investment, power consumption, portability) we employed a vector of ultrasonic range finders as sensors. These cannot all be triggered and read simultaneously due to interferences. Hence, the individual sensors needed to be scheduled and individually enabled, leading to an increasing time lack depending on the number of sensors and depth of sensing (the ultrasonic signal takes some hundred milliseconds to 'travel' through the room). At 25 ultrasonic sensors, however, this lack is hardly observable in many applications of performances and in audience interaction. Here, as with TASKswitch, the advantage of being independent of the light conditions, should outweigh a potential latency lack. Its deployment also seems to be much more undemanding compared to, for example, carefully positioning and calibrating a depth camera like Kinect to accomplish the same purpose of tracking positions on a floor.

We go on to report a first field evaluation of four TASKswitch modules during an interactive opera experience ("The Salome Experience") and subsequently explain our next steps the in developing *The interactive Audience Sensor Kit* (TASK) further.

Field Study Insights

As indicated earlier, we gathered some initial insights and feedback for TASKswitch from a field study. In detail, we deployed an interactive installation using four TASKswitch modules to augment a live opera experience with audience participation. Our overall goal for this initial evaluation was to apply a first and 'real' stress test to the TASK system (TASKswitch). As outlined in the following lines, the occasion of the study was rather 'formal' and the setting was quite complex. Hence, after experiments in the lab, we exposed the TASK system to an audience for the first time with 'no strings attached'.

Figure 6 provides some impressions from this event, which was named "The Salome Experience" and based on the corresponding opera by Richard Strauss. Due to space constraints, we omit further details about the opera event regarding the conceptual/artistic framing (see [8] for more details) and focus here on technical aspects. It was performed by the Vienna State Opera and streamed live over the Internet to the ceremonial hall of the University of Vienna (see Figure 6) where a 'social evening' in the context of a technology symposium took place. In this hall, the opera was presented to the audience (visitors of the symposium) on a 40" TV set. In addition, we projected an animation of a moon and night sky behind the TV set, and we placed four chairs in front of the TV. As each of these chairs was augmented with a TASKswitch module, we could easily integrate them as interactive parameters, and thus create "The Salome Experience". More precisely, we used the information of which seats were occupied to render our projected animation. Depending on where and when visitors sat down, we adjusted the

Figure 6: Field deployment of TASKswitch during "The Salome Experience" (top and middle image). The bottom image shows the scene shortly after the performance with the room-lights switched back on.

trajectory of the animated moon accordingly. (Note, the moon played a central role in this particular opera.)

During this event, we (the first and second author of this paper) observed how the audience interacted with the installation, and we took field notes. In addition, we conducted short informal interviews with people, who had used the installation (i.e., people who sat down on one of the seats). Moreover, we asked the spectators to fill in brief questionnaires, mostly about the user experience of the installation. However, we do not focus on the user experience of the installation in this paper. Rather, we are interested in more technical and broader aspects, concerning the implementation of interactive live events in more general. Finally, we logged all user interaction events during this evening. For this work-in-progress paper (and for our future work) we then did a preliminary analysis of the collected data by revisiting and discussing all notes and observations. We go on to informally report our first insights in the subsequent paragraphs.

Findings from a Technical Viewpoint
Regarding the opera event, the first thing to mention is that we were glad to see that the TASK system behaved as reliable and stable as in our lab tests before. There were no technological glitches during the event. Within the busiest two-hours time interval, the log system registered 232 seat-occupied or seat-released events.

Before the show, we came to the ceremonial hall early in the morning to setup the installation. Within 3 hours we were able to prepare everything and completed the setup successfully (including some waiting time for the technicians to provide access to the projector and other equipment we needed to borrow). The chairs, however, we brought with us and therefore we were able to adjust TASKswitch to them in advance. Still, taken this off-site preparation also in consideration, we can report that the hardware setup of the interactive opera experience was quite straightforward using TASK.

Findings from the Visitors' Viewpoint and Social Aspects
The field deployment revealed many interesting observations that go beyond things that can be learnt in technical debugging sessions, because the social side to live performances often introduces unanticipated complexity and dynamics. In our case, for example, we saw two visitors talking to each other and ignoring the opera installation. In order to better hear each other's voices both persons leaned forward and ended up sitting only on the edge of the chair. This sitting posture, however, we did not expect and the placement of TASKswitch therefore would not allow registering these 'users'.

Other visitors appeared not to be recognizing their influence on the projection by taking or leaving a seat, and thus basically missed the interactive component of the show. Thus, one interview participant suggested: *"Direct feedback would be appreciated. Something real significant should happen".* Others, in contrast, acknowledged our intention to design for subtle and modest interactions, for example: *"I think it totally makes sense for the installation to operate in the background in order not to distract from the actual opera."* Another quite unexpected incident was a man reserving one chair with his jacket and then leaving for beverages.

We could go on describing interesting observations regarding social aspects and the dynamics of the installation. All of these interesting findings around how people responded to the interactive experience were enabled by the rather elementary components of TASK. Therefore, besides regarding TASK as a kit for bringing interactivity to live performances, it can also be seen as a researcher's tool for conducting scientific inquiries into this domain, or for artists who want to test out and improve their performances gradually.

Moving Forward

As next steps, we planned four specific actions, looking into both technical and social/interactional aspects. Firstly, we will deploy seats equipped with TASKswitch (Figures 2-4) on further occasions. This time, however, with up to 20 seats. This will allow us to target field studies on performances with more than a few active participants and test TASK in more complex scenarios. Secondly, we are currently working on the technical advancement of TASKvector, as outlined in the corresponding section before. Thirdly, from a more theoretical perspective, we will use the system to address research questions concerning the *nature* of interactive performance events. The experience with TASKvector, for example, as a more complex input for art installations will pose new questions and challenges around TASK. Besides anticipated technical issues, such as capability and stability, this will concern conceptual considerations, for example, how to make best use of a multitude of TASK sensor data for creating meaningful audience interactions. Or, what 'paradigms' or interaction mechanisms can successfully be implemented using TASK? This research will lead us to engage deeper with the crucial aspects of performance experience and interaction aesthetics.

Fourthly and finally, another defined goal is to develop additional modules with different sensor abilities than TASKswitch and TASKvector (proximity). We already started looking into noise and light sensing modules.

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