Media Crate: Tangible Live Media Production Interface

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ABSTRACT
Live media production – the presentation of audio-visual content at events such as conferences and concerts – is a high intensity task where a small production team must interact with an amalgamation of separate hardware tools to transform and direct a variety of media sources to outputs such as large screens, preview monitors, and web-casts. We present Media Crate, a tangible tabletop interface crafted in response to the key actions and needs of live media producers. Using tangibles, previously complex and ambiguous actions can now become collaborative and easy to learn, whilst providing expressive features not present in traditional interfaces. In this paper we give a description of the Media Crate’s interface, discuss how knowledge and experience of live media production impacts on the design, and finally present the results of an initial deployment of the system at a live event.

Author Keywords
media, video mixing, media production, tangible interaction, portable

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: Miscellaneous

INTRODUCTION
Live media producers present audio-visual media to audiences at live events; these can vary from small conferences, where back-drops for speakers are presented using a laptop and digital projector, to stadium-sized events where as many as 10 members of a team will present media over 20 or more outputs. Media production teams gain control of the variety of inputs and outputs required for the modern day audio-visual setup through a skilfully connected collection of hardware devices; many of which were designed for use in isolation (see Figure 1). Although set-ups such as these enable the creation of highly polished and professional results, they lead to a situation where the interactions of the team are dictated by the need to work around technically complex and often unsuitable hardware configurations. Live media mixing contains similar actions to offline editing, such as choosing in and out points for media, but includes spontaneous media selection and a collaborative working.

We present the Media Crate, a live media production interface which is based around tangible interaction techniques designed to encapsulate the vital actions of media producers. In response to observations and our personal experience of the domain, the Media Crate has interactions which are crafted around the key actions and needs of the live media production team. We also describe an initial deployment of Media Crate at a week long live event where live media producers were given the chance to compare the system to their traditional hardware set-ups. The Media Crate demonstrates how the design of tangible interfaces can be grounded in real world applications.

The Media Crate is an environment for collaborative live media production that allows the composition of live media productions, these may span multiple output devices, from varied media sources. Users can create this content by interacting with virtual and physical objects upon a tabletop surface. The form, interface and interaction techniques of the Media Crate have been designed to enable activities of live media production which were discovered through an observation of their practice, our personal experience of the domain1 and

1Tom Bartindale regularly works as a part of a live media produc-
co-evaluation activities with live media producers. Observations took the form of informal studies conducted at events over a period of. These focused upon observation of the work practices of producers coupled with questioning about the activity of live media production and their equipment set-ups.

Multiple sources and media types

Our observations of live media production highlighted the need to work with a range of varying media inputs and outputs; access to which is realized using complex combinations of hardware playback and presentation devices. As a consequence, the work of the producers may be distributed across an array of hardware interfaces each requiring their own unique methods of control; this has the potential to greatly increase the cognitive load on the producers. In addition, in many cases the devices are not designed to be used in the combinations required by the producer, and therefore large amounts of time can be spent ensuring that devices are connected and synchronized correctly. Finally, many of the devices require a skilled operator; this can prevent novice members of the production team from contributing to the work-flow and lead to divisions between teams where control of certain media sources and outputs are dependent on specific producers. In response to the need for control over a broad range of media inputs and outputs, and the apparent problems caused by the need to interact directly with the devices which implemented these, our design was based around the idea of a cue. The cue is an abstraction of a media source available to the producer as a small thumbnail image on the table surface. By abstracting from implementation, a cue acts as a generic building block for the design of interaction techniques which warrant the basic acts of Media Production, and break away from a work flow dictated by enabling technologies. This affords fluid manipulation of all aspects of the media production; thus lightening the cognitive load on the producers, removing the need for synchronization of devices, and aiding novice users by reducing the number of techniques that must be learned.

Collaboration

Media production at larger events commonly requires up to 5 producers or engineers working in synchrony. Difficulties that arise include: conflicts as producers require simultaneous interaction with hardware devices designed for single user interaction, synchronization and coordination of media sources, and confusion as multiple producers struggle for access to devices which are physically located in relation to their technical connections rather than production need. The solution commonly devised by the production teams in collaborative situations is to create a hierarchical command structure where producers operate hardware devices in isolation and collaboration is mediated by a level of supervisors.

To better support the collaboration which is essential in live media production, and resolve some of the issues which have arisen from the traditional equipment set-ups, two main design decisions were made. Firstly an interactive tabletop has been chosen as the basis of the interface. Substantial research has demonstrated the natural collaboration environment the table affords and how the benefits of this environment can be applied to computer group ware. Such work has highlighted factors such as the role free orientation of artifacts upon a table can pay in creating a fluid and communicative group environment [11], and the ability for collaborative work to be configured across the table in the form of rapidly changing personal and shared work areas based upon the task at hand [17]. Additionally the democratic collaboration environment which the table affords can result in the flattening of group hierarchies, such as those observed in the traditional media production set-up. Often the environment of collaborative media production prove to be stressful, not just through an ever changing media context, but also due to environmental factors such as loud noise, low or erratic lighting and claustrophobic conditions. In these environments it is important to have an interface which is both expressive and coherent when channels of team communication are unavailable. The work in [4] shows that individuals within a team lose focus and attention when under stress, thus reducing the team’s responsiveness and production value.

The second design decision inspired by collaboration was the use of tangible tile objects as the basis for user interaction with the system. Tangible interaction was chosen because the intense and high-paced collaboration witnessed at the larger and busier media productions was predicted to result in the possibility for conflicts in user activity when co-located and interacting with a single interface. Conflict avoidance and resolution was achieved by using the physical properties of the tiles to encode the rules and limitations of the interface. For instance, to scrub through a video media source associated with a preview monitor a tangible object must be placed flat upon the Media Crate surface and rotated. As it is physically impossible to simultaneously rotate a tangible object in two directions about the same axis, the interaction technique enforces the mono-directional nature of video playback.

In addition to physical presence preventing conflicting action in the collaborative interface, the use of tangibles also allows for a high level of visibility of other users actions and the current global state of the interface. The tangibles, due to their visible physical presence, allow an observer or collaborator to gain a rough understanding of what a particular user is doing on the interface, even if the current environment renders the virtual content difficult to view. This raises awareness of individual user interaction and the production state in general; therefore helping collaborators to synchronize their actions. Additionally the physical presence of the tangibles allows for interactions which do not demand visual attention. This encourages face to face communication between the team and allows a user to control properties whilst viewing their results in real time (while looking in another direction to the controller).

On the road
The work of the live media producer is generally at one-off events each held in different locations; this leads to a working model similar to that of a touring musician. Teams have to transport the majority of their equipment to each venue and complete a lengthy set-up process of all the hardware components. Therefore equipment which is practical in the context of a touring event is not just to be a useful factor for the live media producers but a necessity.

![Figure 2. The table’s flight case housing.](image)

As a consequence the form of the Media Crate is designed to be portable and practical in a similar way to how many modern electro-acoustic musical instruments are designed in a manner to allow for ease of transport between events [15]. This affects the hardware configuration as size takes priority over functionality in the choice of components. For example a Mini DLP projector with a low resolution of 800x600 pixels and a brightness of only 50 Lumen is used over a higher specification yet more cumbersome model.

The Media Crate has a much smaller table surface than many previously proposed interactive surfaces, (This size reduces the available screen real estate, an important factor in interactive table design highlighted in work such as [6]), as a result interactions are designed with the reduction of screen space in mind. The tangible objects are also crafted with size as a priority rather than in the optimal physical form for the interactions they are supporting, this allows multiple objects to be placed on the surface by users at any time. In order to allow for smaller tangible objects, a high resolution (1024x768) Dragonfly2 fire wire camera is used, mounted in the base of the unit. Robustness is also a key element designed into the Media Crate; consequently the whole table design is incorporated within a 10U Rack flight case mounted on wheels, and the screen is 10mm acrylic sheet (Figure 2) which allows it to be handled roughly between events.

**RELATED WORK**

**Live Media Production**

Live media production is commonly achieved through the use of hardware playback and output devices combined using hardware solutions such as the Edirol V4 vision mixer [5]. Such components provide tangible control of media which is tailored to the source they represent and create an equipment set-up which can display any media type for which a hardware playback device can be purchased. These set-ups however distribute control of media across a wide range of devices, making synchronization of simultaneous action difficult, and also often require a high level of knowledge to operate each device. A Software based solution to live media production is proposed by MediaShout [14]; the system gives aggregated control of media similar to that of the Media Crate however the interface is WIMP based making collaborative production difficult. Additionally Media Shout defines a different interface for each varied media source thus the system does not afford the fluid and general interaction techniques made possible by the Media Crate’s cue abstraction.

**Media Access and Control**

A range of interfaces related to the manipulation of audio and visual media have strong parallels which can be drawn with the Media Crate. The reacTable [8] is a collaborative computer musical instrument which enables the control of a synthesizer through the manipulation of tangible objects upon a table surface. The simple and intuitive interface of the reacTable, which is based around the spatial configuration of tangibles across a table surface, was a major influence behind the initial concept of the Media Crate. The Media Crate differs from the reacTable in many respects however. Specifically the reacTable focuses on supporting creativity and improvisation through its interface, the design of the Media Crate, although encouraging such characteristics, was necessitated by the Live Media Production domain to place more emphasis on more structured control and a greater level of polish in what is produced. Also importantly, the reacTable only allows for control of audio, whilst a major feature of the Media Crate is the wide array of media it enables interaction with.

The Live Cinema Instrument [12] allows for live control of visual media sources as part of the expressive performance of Live Cinema. The interface is based around virtual clips, similar to the cues of the Media Crate, which can be freely positioned around an interactive surface using touch input. The Live Cinema Instrument differs significantly from the Media Crate however as it is designed for a single user scenario and hence is based upon a vertical interaction surface and a small interactive drum. As with the reacTable, the Live Cinema Instrument does not afford interaction with the varied media sources of the Media Crate.

Media Blocks [20] is a tangible interface which creates a physical presence for on-line media sources and a simple abstraction from the complex implementation these sources may have. Hence a strong relationship between Media Blocks and the Media Crate’s cues can be noted as they allow for fluid and rapid interaction with media sources which previously may have been complex and time-consuming to ac-
cess, and between the tangible output objects which give a physical representation of possibly distant output sources such as web-casts.

Tangible Interaction
As shown by Brave and Ishii [2], tangible interfaces are a natural basis for group collaboration and interaction, and allow even distant collaborators to gain a much richer interpretation of other’s actions and the status of shared data. By using physical tangibles in a local environment, communication between collaborators is on a much more personal level, and removes some of the need for verbal explanations of actions. Kaltenbrunner et al [10] describes how visual feedback of tangible manipulation is vital for the user to understand and interpret both their own and other’s actions correctly. They also describes the use of totally passive objects, which enable manipulation of the interface without the need for wires, batteries or specific user equipment. This is an important design factor when designing portable devices and equipment, due to wear and tear.

Tabletop Interfaces
A wide range of research has explored how the natural collaboration environment of the table can support co-located, and distributed, group interaction with computers. Factors and their impact upon the interactive table as a collaboration environment have been explored such as the role of orientation [11], territory on the shared tabletop [17], coupling across varying group tasks [19], and group coordination and conflict resolution [16]. This work, and others like it has had a significant effect on the design of collaborative aspects of the Media Crate; inspiring the choice of a horizontal surface as the basis for the interface, and influencing its interaction techniques. For example, cues were designed for flexible relocation to allow for transition between personal and shared work spaces, as seen in the UbiTable [18], and tangibles were used to enforce conflict resolution in situations, such as those described by Ringel-Morris et al [13], where social protocol may be broken in the high-pressure media production environment.

THE INTERFACE
The finite actions essential to live media production appear to be direct and focused around the achievement of simple goals. Thus, the Media Crate interface is based upon finite interactions which each represent an essential action of live media production. A ”clip” is defined as a media source, whether live or recorded, the following actions apply:

- Preview a clip
- Add a new clip from a source (source needs to be chosen from a number of options, and/or file resources)
- Edit the properties of a clip.

A ”cue” is defined as a prepared clip, loaded ready to output, these actions apply:

- The ability to play an ordered list of cues on one or more screens simultaneously.
- The ability to cue (arrange) clips ready for playback, the arrangement could be conceptual or in an ordered form.
- The ability to loop a list of cues.
- Move between cues in a controlled manner.
- Ability to move between sub cues (such as slides in a presentation).
- Ability to display a cue on an output.
- When a cue finishes, what happens next should be configurable.

Figure 3. Icons on the tangibles representing primary media actions.

Where possible, each of these primary functions are realized through the manipulation of small tangible tile objects in order to provide both a direct link between action and reaction for the user, and provide inherent understanding of all processes on the table to all users. By using tangible objects, the interface becomes more familiar to users of older media hardware, which is based around physical controls linked to specific functions, and allows for a quicker learning curve. Figure 3 shows the simple icons representing primary actions on the tangible tiles themselves.

Cues
A cue is the basic building block of Media Crate’s interface. Each cue is a small virtual thumbnail image displayed upon the table surface which represents a media source available to the producer. The source of a cue could range from a simple video file on a local machine to a live-feed from a camera at an event. Cues can be dragged around the interface with the fingers of the media production team or with a generic tangible object. The cue allows the media producer to abstract from the implementation of a media source and simply interact with it as if it is a component of their production. This abstraction allows for a level of generalization which is essential in the creation of the fluid interactions. It turns the standard linear action sequence into a distributed one, allowing multiple points in the sequence to be managed at any one point in time.

Output and Preview
The action of switching between outputs is a common and rapidly completed behavior in media production. As a consequence the interaction to facilitate the association of media sources and output/preview devices was design with simplicity and fluidity as the highest priority. Each output/preview tangible is associated with an output device, or preview mon-
Properties Edit and Control Knob
In contrast to output and preview assignment, the editing of properties is required in the production process but completed relatively infrequently. Therefore, it was decided to spatially dislocate manipulation of properties toward the edge of the interface so as not to over-complicate the interactions directly associated with cues. Alterations to properties are often precise and expressive, so the actual interaction with properties is realized through the rotation of a tangible object rather than with touch input. To edit properties, a tangible is placed upon a cue to bring up a small panel toward the edge of the table surface; this presents the properties of that source. A generic control knob tangible can be placed on each property in the panel and rotated to alter either continuous or discrete values.

Cue List
Media productions were observed to comprise finite sets of media cues in sequence. Although playing each cue in a sequence would often require a great amount of interaction with, and synchronization between, a plethora of hardware devices; if no unforeseen circumstances arose, the sequence would remain static and unchanged at the time of presentation. Hence it was noted that rather than the action of displaying a single media source being the action important to production, it is actually the initiation and control of sequences.

In response to this, the cue lists are designed to encapsulate the presence of, and control over, a sequence through a single tangible object and a simple rotational scroll interaction. Additionally, as sequences are rarely interacted with when not being created, edited or displayed, the cue list is designed to provide a way to physically store sequences away from the interface ready for rapid acquisition and use.

Interaction with a cue list allows grouping in play list configurations for sequential playback (using a cue list tangible.) When a cue list tangible is placed upon the table surface, a virtual circle appears around it; users can drag cues into this circle to add them to the sequence. To play the list, an output tangible can be placed upon any of its cues. Once a cue has finished playing, the circle around the list will rotate placing the next cue under the output tangible. Users can scroll through a cue list by rotating the tangible, and a cue list tangible can be removed from the table to save its configuration for later use. Figure 4 (Item 1) shows a cue list with an output tangible placed on a cue, initiating playback.

Copy/Paste
Reconfiguring of the structure of a production during a live event is a high-intensity task. Often complex manipulations of various hardware devices are completed in response to unexpected situations. The copy/paste tangible is designed to
allow for media to be shifted and duplicated between parts of a production with a rapid action even when under pressure. Both actions copy and paste were included into the single object to allow for the two actions to be completed in one fluid gesture – additionally the single object allows for a cue to be directly associated with the tangible, and hence given a physical representation, throughout the interaction, thus preventing confusion if multiple copies are made in the heat of the moment. The Copy/Paste tangible itself is a tile which has two faces. One, copy, when placed on a cue will associate that cue with the tangible and the second, paste, will duplicate any cue associated with the tangible at its position on the table. A stack is maintained associated with the tangible for multiple copy and paste actions.

IMPLEMENTATION

The implementation of Media Crate can be broken down into two major categories; multi-touch sensing and tangible object tracking, and media management.

Multi-touch and Tangibles

The tracking of user touches and the tangible objects placed upon the table is handled using the reacTIVision optical tracking system. A high resolution fire wire camera which operates at a frame rate of 20fps and a resolution of 1296x964 pixels was used in combination with 4 arrays of 880nm infrared LEDs which illuminated the table surface from below. Further details of the operation of reacTIVision can be found in [1, 8]. The position of touches and the location, rotation and identity of tangible objects is transmitted to the interface on a local UDP port using the Tangible User Interface Object (TUIO) protocol [9].

External Media and Output Devices

Access and control to media sources represented by The Media Crate’s cues is handled by a software module based upon a plug-in architecture. Media output devices with plug-ins implementing a common interface enable the abstraction of access and control seen in the output tangible object. Output plug-ins contain common actions such as play, stop, next and previous sub-clip and information on what that device can render. The primary renderer used in the Media Crate at the present is a wrapper for VLC, an open source media player, other renderers however could be utilized including web browsers, or the transmission of text messages.

This plug-in approach allows for access to the breadth of media devices and sources required in Media Production. Most interestingly plug-ins can be created to support media sources and output over a network (Figure 5); this could remove the need for the dependence on co-location of the production team, their media and event’s output devices.

EVALUATION

As part of the agile development strategy for developing Media Crate, series of prototypes were evaluated in the lab and refined to produce major milestone prototypes. These milestone prototypes were evaluated using two primary methods, group co-evaluation and live-context evaluation.

Evaluation 1: Co-evaluation

To assess the suitability of the interface design, the Media Crate was presented to a group of 6 producers in an afternoon co-evaluation in our lab. The producers were given a list of tasks to complete with the interface whilst being observed by video cameras. The tasks involved a set of discrete steps, each representing one stage in the process of setting up and displaying a cue. Afterwards, a group discussion was held where different aspects of the system were brought forward and critiqued, and finally, personal preference and feedback was given through questionnaires. Other than a simple explanation of placing tangibles on the surface to produce results, no specific help was given to the participants. The tasks were designed to be flexible enough to give the producers the freedom to be creative in their use of the interface but also to ensure that all elements of the interface were experienced at some level. Set tasks included:

- Create cue lists – Introduce users to the system and allow them to organise clips collaboratively, using varied input sources. This task also allowed the users to discover what action each of the tangibles performed on the table.
- Play sources onto specific outputs – Test usability and functionality of the system, by instructing users to perform specific actions, but not how they were to be performed, the interface was tested both for its flexibility and intuitiveness.
- Edit source properties – Discover any ambiguity in the interface, as property editing is a task performed individually, using accurate movement.
- Run through script – Investigate how multiple users on the table interacted when put under pressure to perform actions. This tested how users directed tasks and how control structures developed between them.

To gain coherent results from the evaluation, both the questionnaires filled in by the participants and observations from footage analysed afterwards were collated into categories, the most interesting insights of which are discussed here.

Evaluation 2: Live Evaluation

To gain insights into the effectiveness of the Media Crate in facilitating the primary actions of the live media producer, an initial deployment of the system was carried out in the...
context Media Crate was designed for; a high tension, multi-user media production in a venue unknown to the designer (ECG Conference, Welsh Theatre, Llandudno, Wales). Both the Media Crate and the traditional equipment of the production team at the conference were set up side by side. The two systems remained in place for the week-long event and members of the 40 strong media production and technical team were encouraged to experiment with the interface and shadow the traditional equipment set-up during the live event. In order to allow the users’ experience with the Media Crate to be as realistic as possible, the unit was transported, set up, configured and operated by the same producers who would be operating the traditional video set-up at the event. Figures 1 and 6 show both the traditional set-up and the Media Crate both at the ECG conference.

Observations

Design

One of the major aspects brought forward in evaluation was that the interaction with the system was unresponsive. This meant that actions which should otherwise have been intuitive using tangibles were actually hindered due to the user waiting for the system to feedback its current status. One user spoke of tangible labels being too abstract, but that by trial and error, functionality was quickly learnt. The design of the unit was praised for being rugged and transportable, although it was recommended that thought should be put into either raising or lowering it to a height usable for long periods of time. If too many tangible objects were on the surface at a time, there were issues regarding how much information could be displayed on the screen.

Tasks

During the evaluation, users communicated between themselves verbally but also by observing and continuing another’s actions at specific points. These points were usually when a different function was to be performed to a source clip, such as a properties edit, or output. Often different users would perform these different actions, depending on whether they were in possession of the correct tangible object, or if they were physically closer to the required source on the table. Often entire tasks were passed between users in order that they be kept conceptually together in locality on the table. In this sense the size of the table was a restricting factor in their decision making process, but actually enabled the group to split tasks according to factors other than team hierarchy. Tangibles were primarily moved with an entire hand or large gesture, allowing other users of the table to visibly recognise another user’s action, a feature small finger touches or movements would not allow.

Collaboration

The ability to perform multiple actions at once became instantly apparent to the users, although because all actions were coherent and visible to all users, we found that often a single user would perform an action while others watched. In this sense a linear command structure was formed relative to the actions needed, rather than team structure. This allowed the team to be restructured depending on the tasks being performed. An issue raised was the editing of properties which required textual information to be displayed on the surface and thus was dependent on the user’s location, hence making others unable to observe.

Personal Response

The response of the producers to the interface was positive, however criticisms of the lower level design of various elements were raised. Interestingly the ability of the interface and the tangibles to be easily reconfigured allowed the producers to rapidly create mock-up scenarios and interface alterations to illustrate points in the design discussion, even though the table was turned off. This illustrates the concept of “Performative Meaning” in relation to tangible interfaces as highlighted by Hornecker [7].

Live Testing Response

The deployment highlighted a range of interesting points about the Media Crate. These included areas of the interface and interaction techniques which could be improved in later versions of the system. For example cues were considered to be too small, output tangibles were noted to decrease awareness about media playback as the object would obscure the video below them, and more visual feedback is required to inform as to whether an interaction, such as copy and paste, has been completed. These points will be fed into the design of next Media Crate prototype to enhance the interface and interaction techniques. In addition to criticisms and potential improvements, the evaluation raised positive comments on the Media Crate; most notably the interface was enjoyable to use and its playful interaction techniques were not daunting to novice users.

Conclusion Future Work

The responses of five media producers to the system during our initial evaluation proved positive, highlighting the potential for the continued development of the Media Crate. This
continued development will firstly tackle issues and potential improvements to the interface highlighted in the evaluation session. Additionally the development and evaluation of the Media Crate highlighted interesting streams of research which can be explored with continued work on the system; for instance the support of collaboration in high-tension scenarios such as Live Media Production, Music Production and Event Management. The hardware also acts as a proof of concept for creating small form factor and portable tangible interfaces which can then be used in a variety of new environments.

The Media Crate aims to show that media production functionality can be represented using tangible interfaces, but also that there are a set of rules which govern tangible interface design in other high tension, high mobility environments. Team activities in high stress environments benefit from easy communication and dissemination of information, so the use of an intuitive and tangible interface which allows users to communicate using methods other than voice is an obvious advantage. Using tangible and tabletop interfaces in media production scenarios can teach us much about implementing these interfaces in wider contexts. In real world scenarios, physical objects can be represented using tangible objects, whose inherent constraints can be naturally mapped to the physical, as seen with outputs in Media Crate. Often, collaborators must work together amongst distractions and with uncomfortable environmental factors, by using tangible objects, the state of the interface at any time can be seen with a glance, but also users interactions with the interface become much more coherent, as they are physically manipulating an object. The creative and expressive properties of tangibles can be exploited in these same scenarios, enabling properties to be controlled without the user looking at the interface, instead at the real world results of their actions. Tangible controls also benefit from a human ergonomics standpoint, as new users will more easily become accustomed to physical controls than virtual ones, reducing learning curves.

REFERENCES


