Domain-specific data physicalisations enabled by DataLev

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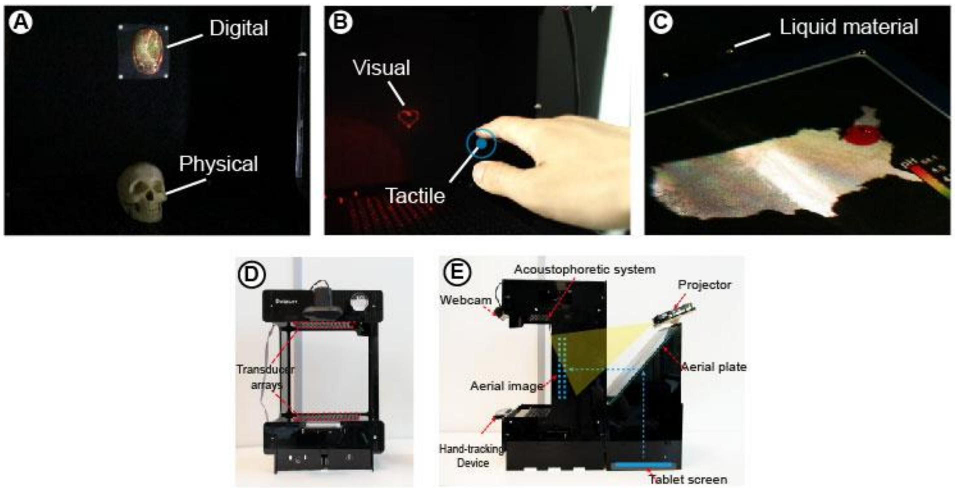

Figure 1: DataLev enables the design of new types of acoustophoretic physicalisations featuring with (A) mixed-reality animation (context: scientific data), (B) multi-modal interaction (context: heart rate data) and (C) enriched materiality (context: pH level of acid rain). DataLev platform comprises acoustophoretic system (two transducer arrays in (D)) and other components (e.g., aerial plate and projector)

1 DATALEV & EDUCATION

DataLev [4], a design space and platform exploiting data physicalisation and acoustic levitation to create reconfigurable artefacts with enriched materiality, multi-modal interactions and mixed-reality animations. The design space outlines five main dimensions: *Embodiments, Materials, Multi-modal support, Mixed-reality components*, and *Animation* to enhance data physicalisation through acoustophoresis. Compared to other electronic platforms (e.g., shape-changing displays, swarm robotics), DataLev allows the material-agnostic objects (e.g., solid, liquid, and edible materials) manipulation in mid-air and can provide multi-modal sensation (i.e., visual, tactile, auditory, olfactory and gustatory) relying on the single acoustophoretic principle. By introducing hybrid digital imaging and path planning techniques, DataLev enables complex animation in a mixed reality environment without wearing additional devices.

Physicalisations have been applied in different domains (e.g., public display, accessibility, communication, and education [2]), with educational physicalisation being a particularly broad application domain that covers many topics, data types and diverse audience. However, only a few physicalisation works (e.g., [6] [5]) specifically claimed for educational purposes, like help understand abstract concepts, improve learning efficiency, and we still face challenges in terms of specific design guidelines and analytics requirements and evaluations. Here, we focus on leveraging DataLev in a specific domain — Education, and outline the current challenges of educational physicalisations and potential opportunities enabled by DataLev.

2 CHALLENGES IN EDUCATIONAL PHYSICALISATIONS

To apply the physicalisaiton appropriately for educational activity, some key aspects need to be considered carefully from intuitive design mapping, physical analytics and proper evaluation. Those factors could be adaptable across other domains.

1) Intuitive design mapping

Though general design space has been proposed in recent researches [4][1], it is still important to build the perfect mapping between education purpose, data context, interaction approaches, materials and embodiments, etc. Designers may need interdisciplinary knowledge from different domains to create acceptable and intuitive designs among the rich design channels.

2) Physical analytics

Compared to visual/digital analytics, using physicalsiaiton for analytical tasks, it is equally important to make the physicalisation informative, readable and interpretable, particularly for educational physicalisations. Some issues should be solved in the pilot test like modality choice, voiding change blindness, distractive presentation, reduce the cognitive loads and bias (occlusion, ambiguity).

3) Proper evaluation

To verify the effectiveness of physicalisaion for educational value, researchers will need to set a valid baseline for comparison and controlled experiments. Setting up proper evaluation metrics (e.g., interpretation, memorability, engagement, problem-solving) will also help to discover implications for future physicalisation applications in other specific domains.

3 OPPORTUNITIES ENABLED BY DATALEV

1) Adapting to various educational topics

DataLev allows the enriched materiality fitting various educational topics, enabling situational and intuitive designs. For example, in physics class, it is more intuitive for DataLev to render the haptic sensation on users' hands so that they can understand abstract physical variables, like force, velocity, frequency and pressure in a straightforward way. To deliver chemistry knowledge, as DataLev allows the levitation of different liquid materials with flexible animations, we could demonstrate real substance motion and chemical reaction in a lively way which is impossible for traditional teaching by texts or digital demonstration.

2) Improving interpretation levels

The levitated Mixed-reality components in DataLev add both tangible, physical components and versatile digital capabilities. DataLev enhances Focus + Context demonstration by seamlessly integrating mixed reality presentation, which could be helpful for users to focus on interested data with enough context information. Besides, additional elements such as axes, texts, and legends could be dynamically added to the physicalisation, which makes users interpret and analyse data easily.

3) Allowing collaboration activities and comparable conditions

The multi-modal support and mixed-reality presentation in Datalev can not only allow immersive interaction but also make it convenient for co-located collaboration without wearing any head-mounted device and communication issue in immersive analytics [3]. As for collaborative educational activities (e.g., group discussion and group work), it would be more practical for students to use DataLev in face-to-face classes and, thus it is also easier to make performance comparisons with other traditional conditions and get practical evaluation results.

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