Replicate and Reuse: Tangible Interaction Design for Digitally-augmented Physical Media Objects. Gupta, et al. CHI. 2020.

What are the core research questions addressed by the work?

- How would one design for digital content perusal when overlaying content over corresponding physical objects such that the physicality of the experience remains intact?
- How do we understand and design for the right level of replication of physical actions, and for seamless methods for reuse?

What motivates the work?

- Users place value on physical experiences, like paging through an album or holding a newspaper
- Although users place enjoy and value physical experiences more, they more often consume media digitally due to its scale and "up-to-date" nature
- Overlaying physical objects with digital content with augmented reality is a promising avenue for bridging the gap of user preference for physical experiences and the more frequent use of digital devices for media consumption

How does the work understand the usage, capabilities, and limitations of paper?

- While users find using physical media objects (paper included) satisfying and enjoyable, they are neither scalable or "up-to-date," and therefore less practical for modern day uses.

What is the target application domain of the work?

- Multiple prototypes are implemented as probes
- "Augmenting" the photo viewing experience
- "Augmenting" the news reading experience
- "Augmenting" the research paper reading experience
- "Augmenting" card games
- "Augmenting" Jigsaw-puzzles
- By "augmenting", we mean the enabling of the replicate and reuse of physical objects, thereby converting the physical object into a sort of digital content-physical object pair

What are some proposed extensions to paper proposed by the work?

- Enabling the reuse of a physical object for new digital content
- Digitally extending a physical object while replicating the physical experience

How are the proposed extensions implemented?

- Marker-based HMD augmented reality
- The Vuforia AR SDK to track markers
    - Overlay of digital content on fiducial markers
- The Microsoft HoloLens as AR glasses
    - Enables voice and gestural input

What are the results of the work? What are the implications of the results for future designs and implementations of paper-based technologies?

- The concept of using physical objects to peruse digital content was appropriate for relaxed use (e.g., a way of unplugging digitally, in contrast to the goal-driven use in digital context)
- The concept of using physical objects to peruse digital content could overcome issues with shared digital use
- There are potential environmental benefits to the concept of replicate and reuse via AR
- The concept of reusing via AR could retain the physical experience while overcoming the physical size, space, and location constraints
- Physicality is sometimes functional as opposed to purely aesthetic (“A physical book in a book shelf tells me its thickness, number of pages….”)
- Digitally augmented physical objects were perceived by some as more disposable than physical and digital objects
- Digital access might have implications for the physical experience
- There is a preference for subtle digital features that overcame constraints in physical experiences, without disturbing the experience too much
- Voice is a good middle-ground between physical, but occasionally tangible control mechanisms and quick, but attention-demanding smartphone interactions
- Browsing interactions should replicate the physical browsing experience
- For physical manipulation interactions, we should adhere to their physical analogues as much as possible
- For reusing interactions, there are no physical analogues and so we turn to additional tangible gestures with the object, or use other modalities voice, smartphone
    - Two factors at play here:
        - Does the new modality require context switching
        - Does the reusing interaction interfere with the physical experience
- Voice+Deictic gestures offer a nice middle-ground for reusing and physical manipulation interactions since it does not interfere with physical browsing interactions and at the same time does not force the user to switch to another device
- Voice may not be suitable for digital manipulation interactions beyond simple manipulations
- Technology needs to mature for such replicate and reuse experiences to truly be inseparable from physical ones
    - For AR glasses and marker tracking: (1) lighter-smaller glasses, (2) larger FOVs, (3) occlusion robustness for marker use, (4) marker tracking invariance to lighting conditions, (5) depth mapping for markers to display overlapping images correctly