

# HARP: A Framework for Visuo-Haptic Augmented Reality

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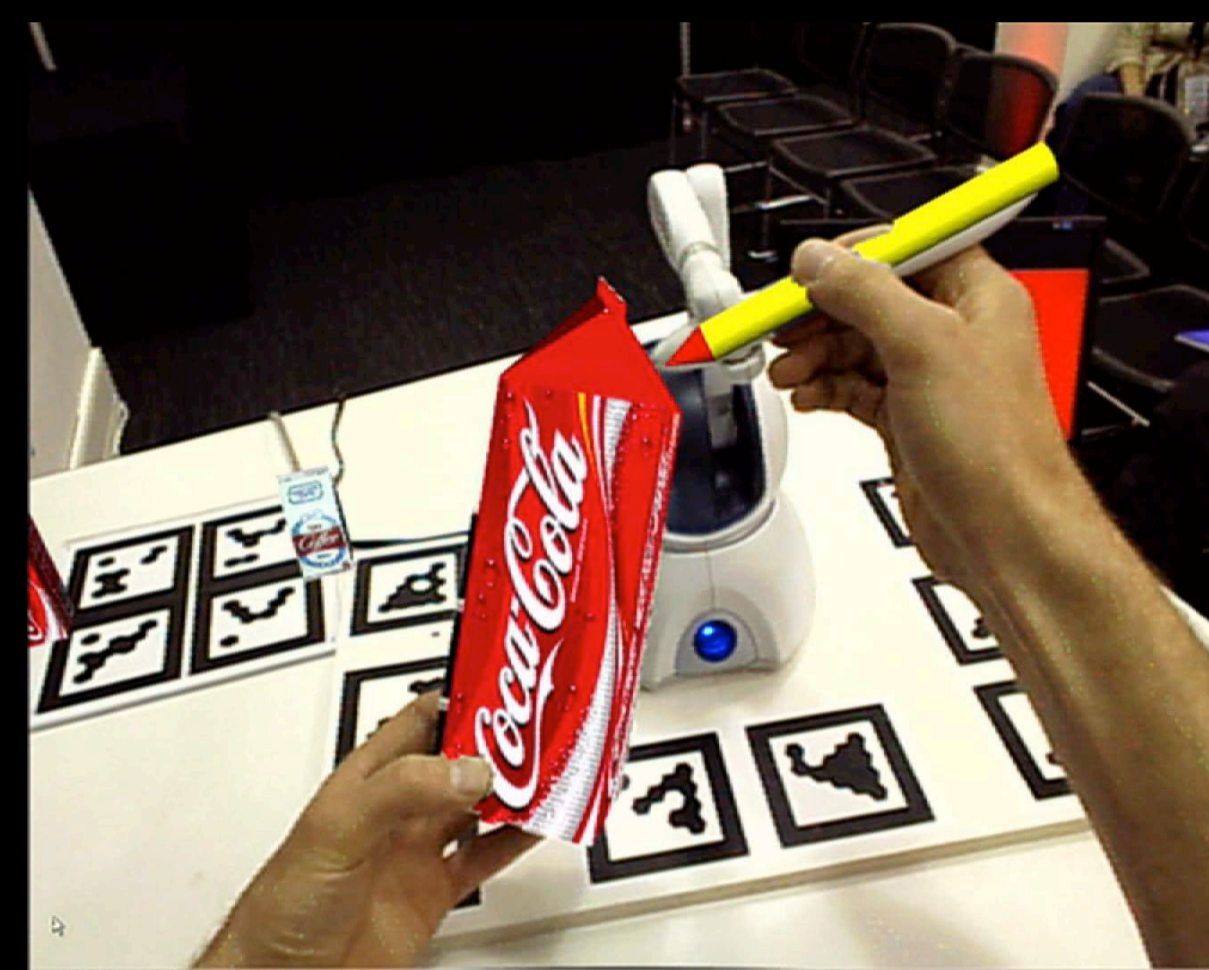
Magic Vision Lab  
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VHAR setup with a head-worn display and a haptic device



Virtual tools are overlaid onto the haptic device



Haptic interaction with tracked objects



Verification of psychophysical phenomena like the Stroop effect in VHAR

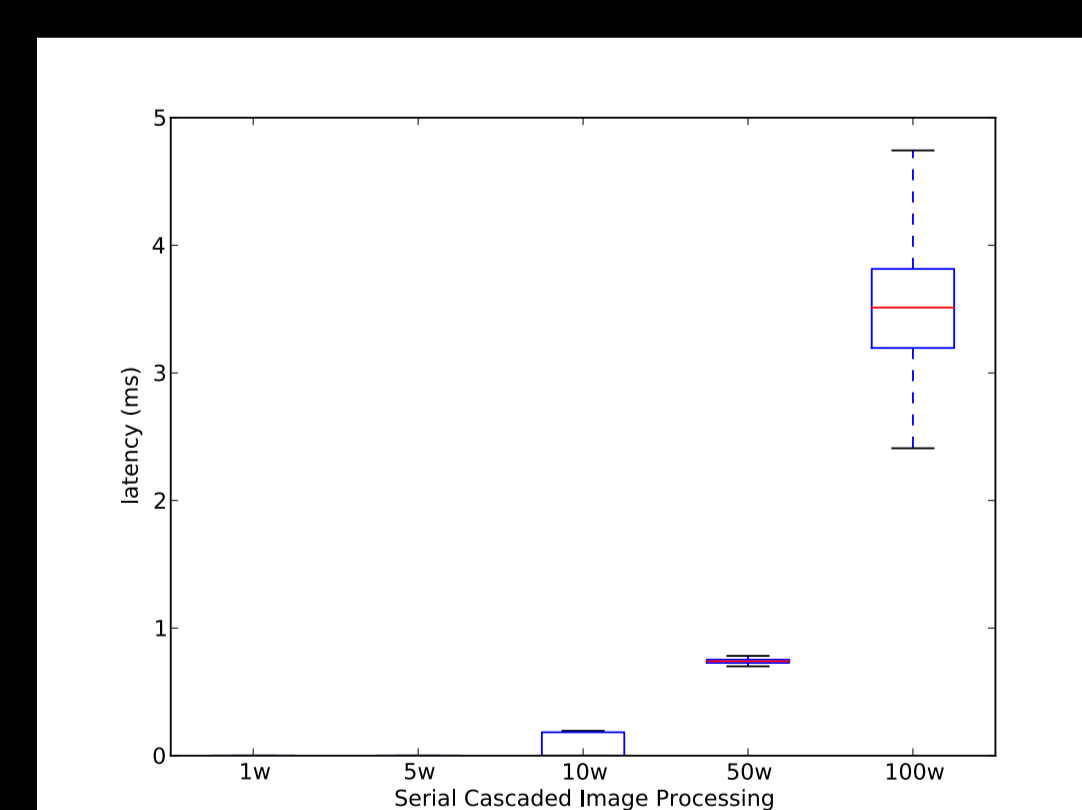
## System Design

- Functional Requirements:
  - Precise augmentations and tracking
  - Accurate colocation of haptic device
  - Realtime operation (haptic 1000 FPS, visual 30 FPS)
  - Low latency
  - Support for haptic devices from multiple manufacturers
- Non-Functional Requirements:
  - Simplicity: suitable for undergraduate student projects
  - Reusability, Extensibility: component based architecture
  - Record / Playback of realtime data streams
  - Efficient workflow for scene creation

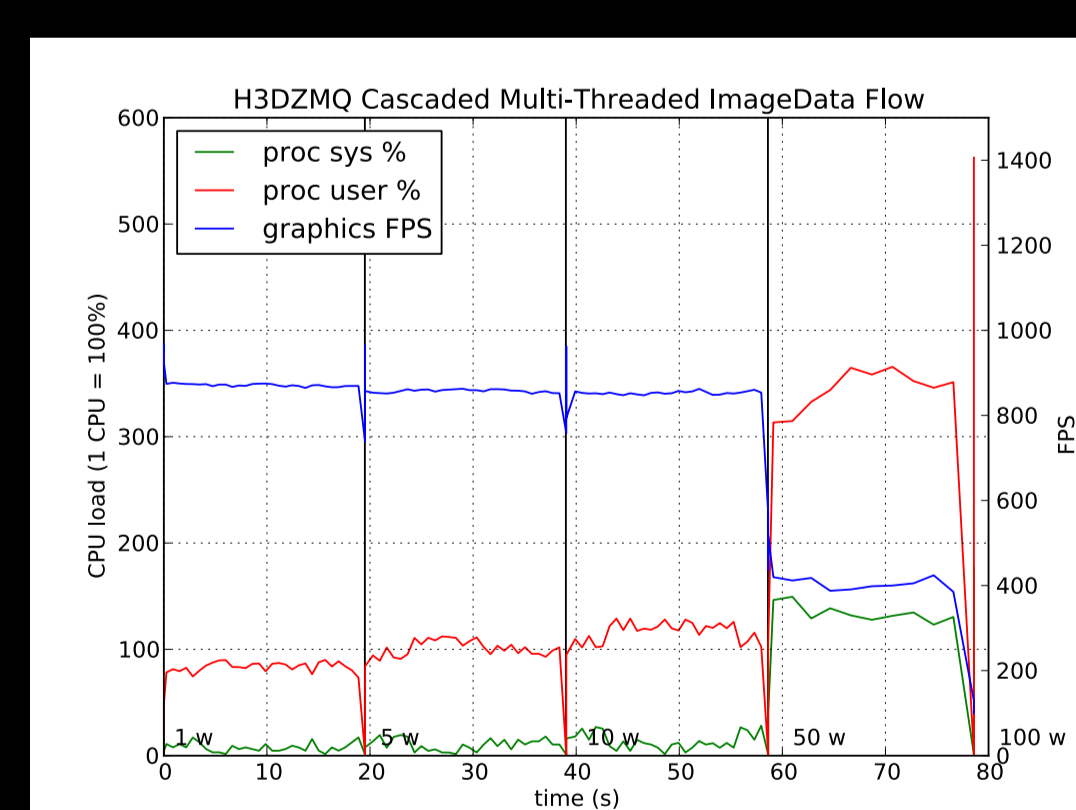
## Implementation

- External Dependencies:
  - H3DAP1 / HAPI: haptic enabled scene graph library, X3D compatible, Python Scripting
  - Canon MR-Platform: mixed reality toolkit for tracking, sensor fusion, and hand segmentation
  - ZeroMQ, Protobuf: Inprocess messaging layer for concurrent stream processing
  - HDF5: file database for temporal stream recording

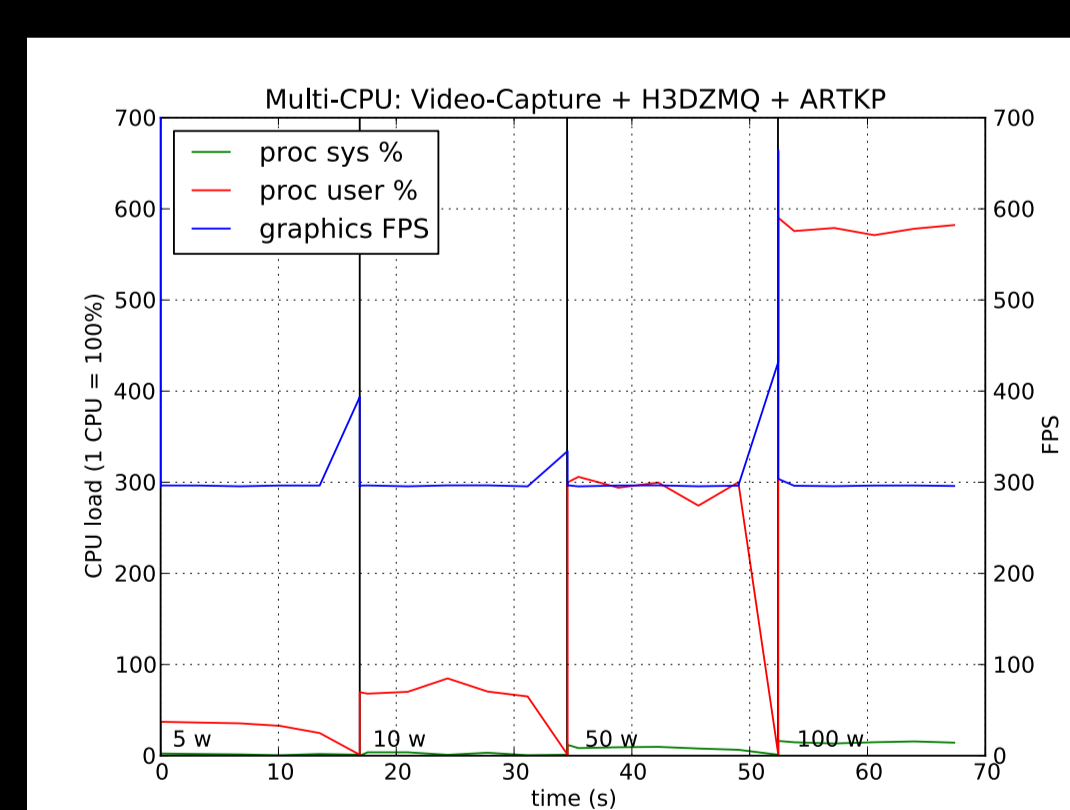
## Evaluation



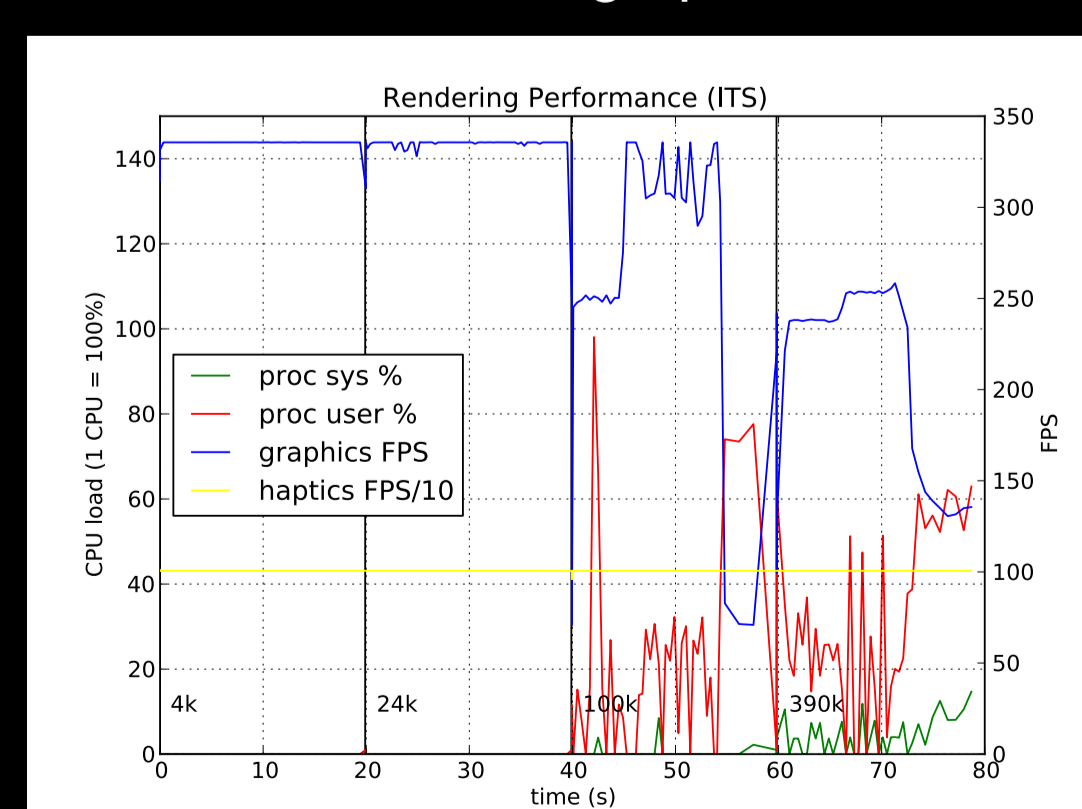
Latency of message passing for cascaded RGB image processors



CPU load and frame rates for cascaded RGB image processors



CPU load and frame rates for concurrent image processing using ARTToolKitPlus with async capturing



Visual and haptic rendering performance (Number of Vertices)

### References:

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