Peekaboo – Head Gesture Recognition on HoloLens

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Keywords
- Head-Mounted Devices (HMD)
- Fatigue: a subjective feeling of tiredness that has a gradual onset
- Dwell time: time spent in the same position, area, stage
- Degree of Freedom (DoF): each of a number of independent variables factors affecting the range of states

Background
- HMDs gaining more popular in VR/AR/MR/Game, etc areas
- I/O interface stayed behind development of HMDs
- People with disabilities need special assistance, which is far underdeveloped
- User interface is non-intuitive and easily causes fatigue in using

Objectives
- Intuition: substitute traditional I/O devices, such as keyboards, mouse with more intuitive ones when in context of HMDs
- Hands-free: achieve real hands free interaction without social awkwardness yet with more accuracy

For our project specifically:
Replace inbuilt clicker-based / hands-free input control of HoloLens by applying Head Gesture Recognition Algorithm on Nodding.

Study One:
- Design user friendly display screen on HoloLens
- Gather Nodding / non-nodding data for later algorithm training and false positive reducing

  - ) on the limitation of human neck movement, which then determine the limit of head movements:
    - X-axis: 45 to -55
    - Y-axis: 70 to -70
    - Z-axis: 40 to -40

  Test screen from user direct view
  40 points in total with 8 points per different percentage of the max limits (100%, 90% 80% 70% 60%)

Part one:
- Ask user put on HoloLens
- Present the previous designed display with only one random order dots show up each round
- Collect data for nodding
- Record feedback
- Exception mode for unreachable / impossible action
- User keep body fixed with only movement in neck
- Analyze cumulative feedback to redesign display screen that 100% reachability
- Nodding data for training nodding recognition algorithm

Part two:
- Collecting data for using HMDs in social scenarios that might trigger nodding recognition as false positive
- Feed those data as negative training to reduce false positive rate of Head Gesture Recognition applied on recognizing Nod

  - ask user to walk around with HoloLens on, collecting data
  - ask user to go shopping at convenience store with HoloLens on, collecting data
  
Study two: (in progress)
- based on feedback data collected in user study one about different dots of limitation, design appropriate display screen that with 100% reachability for our sample users.
- Design and implement algorithm for recognizing nodding (using Hidden Markov Model for current stage) using collected nodding data from study one
- Feed in noise data from part two of study one to reduce false positive rate
- Conduct further user study for three hands-free methods and compare their feasibility
  - Head gesture (nod)
  - Head dwell
  - Hand gesture (default for HoloLens)

Challenges
- Humans good at adapting and learning, which leads to impatience toward fatigue when too familiar with HoloLens
- Algorithm’s hard to be zero false positive and the efficiency of algorithm would become limiting factor in the future
- Dominant use of HMDs is hard to anticipated, which makes it harder to disguise appropriate way of user interface design

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