Enabling an Augmented Reality Ecosystem: A Content-oriented Survey

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AR: Augmented Reality

- Augments real world with virtual objects
- Superimposes computer generated objects onto user environment
AR Characteristics

- Combine real and virtual objects in a real environment
- Run interactively in both 3D and real time
- Align real and virtual objects with each other
Augmented Reality Technologies

- Optical see-through
  - Google Glass
  - Vuzix Star
- Video see-through
  - Oculus Rift
  - Sony’s Project Morpheus
AR Ecosystem

- Third Party Company
- User
- Sensor
- AR Device Manufacturer
- Display
- Tracking
- Local Broadcasting
- AR App Developer
- Computer Vision
- Academic Researcher

Content Provider

Ecosystem
Enabling the AR Ecosystem

- Data collection
  - How to collect data?
- Content Fusion
  - How to combine data?
- Content Display
  - How to display data?
Data Collection

- Via local/onboard sensors
  - Accelerometer
  - Gyroscope
  - GPS

- Via sources from Cloud
  - Rich set of API’s provided by third parties
  - Crowdsourcing
Direct-field sensors

- Measure strength of a field
  - Magnetic
  - Gravity
- Sensitive to electromagnetic distortion
- Accuracy degrades with distance
Does distance affect Sensor?

Gravity (ms\(^{-2}\))
Inertial sensors

- Rate of rotation (unit: rad/s) around a axis
  - Gyroscope
  - Accelerometer

- Calibration errors
  - Needs to be re-calibrated often
Location sensors
  - GPS
    - Power intensive
    - Poor indoor reception
  - WiFi
    - Approximates location
    - Works indoor

Location services are very important for delivering content-specific objects
**DC: Sensor Drawbacks**

- Easily distorted by interference
- Some may be energy intensive
- High latency experienced with low sampling rates
- Some may need user calibration
- If a sensor fails there is no fallback option
  - Will degrade user experience
DC: Cloud Server

API

| Location | Places | Routes | ...
|----------|--------|--------|------
| ...      | ...    | ...    | ...  |
Content Fusion

- A pipeline to keep captured information consistent, accurate and informative
- 3-tiers:
  - Database
    - Data acquired from third party
  - Delivery
    - Restructuring of data to meet specific use of app
  - Content recommendation
    - Used by different applications
Content Fusion Pipeline

1\textsuperscript{st} Tier

Sensor

Database

Deliver

3\textsuperscript{rd} Tier

Application

Users

Raw Data

Structure

Content Package

2\textsuperscript{nd} Tier

Third Party

Cloud

Online Selection
Content Fusion (cont.)

- Offline data preprocessing
  - Download standardized format content packages
  - Structure information using content fusion pipeline
- Online content selection
  - Selection of information is done in real-time
  - Automatic content filtering and selection
Third party API’s for content packages
- Google
- Wikipedia
- Yelp

Packages may contain
- Redundant information
- Stale information
Any object, of any type, at any point in time, can become sufficiently important when it passes filtering criteria.

Certain objects are important to all users at all time.

Some objects are only important to particular users.

The amount of information shown to a user about an object is inversely proportional to the distance of that object from the user.
Online Content Selection: Filtering Criteria

- **Distance-based filtering**
  - Works on pre-set threshold
  - Visibility based on object’s distance from user
  - Touring Machine
    - Brightness of labels increases as user moves closer

- **Visibility-based filtering**
  - Visibility of virtual labels based on actual visibility of the real object
  - An advantage for small screen sizes

- **Advanced filtering**
  - Establishes a spatial model
  - Uses focus and nimbus to determine importance of object
Head mounted displays (HMD)
  - Optical see-through
    - Google Glass
    - Advantage:
      - Safety
      - No eye offset
      - Easy implementation
  - Video see-through
    - Oculus Rift
    - Advantage:
      - Wide field of view
      - High resolution
      - Consistency in luminance
Projection Displays

- Projects 3D objects onto visible surfaces
- Does not require user to wear anything
- Luminance compensation is needed to overcome uneven surfaces
- Works best in dark/low-light areas
- Real-time masking
  - Selectively project on parts of a scene
- Handheld displays
  - Mobile devices
  - Disadvantages:
    - Limited computing power
    - Limited battery life
Current Trends and Issues

- Tracking and Registration
  - Sensor-based tracking
    - Limited by accuracy
  - Vision-based tracking
    - Limited by scope and power consumption
- Handling unobservable and dynamic environments
- Location reconstruction from incomplete data
Current Trends and Issues (cont.)

- Mobile and AR devices
  - Limited by their computational power and battery life
- Energy-efficiency and Cloud Computing
  - ThinkAir
    - ThinkAir is a framework for offloading mobile computation to the cloud, with the ability of on-demand VM resource scaling.
    - Provides dynamic resource allocation and parallel execution in the cloud
Content Fusion

- Degraded information precision with unstructured data
  - Content selection and fusion using AI
  - Machine learning techniques to structure data
- Need powerful device and/or large memory for complex algorithms
  - Modified algorithm to fit need of mobile devices
  - Offload heavy transactions to cloud
Current Trends and Issues (cont.)

- **Privacy Issues**
  - Overlaying information obtained from Facebook over the image of an individual’s face
  - Overlaying other private information
    - Street Address
    - SSN
    - Interests

- **Security Issues**
  - Not with AR technology, it is more on how data is handled with offline and online content selection
Reconstruction of archaeological sites
- Reconstructed with the aid of Touring system
- Advanced filtering techniques

Surgery
- 3D virtual presentation of soft tissues
- Using X-Rays to construct 3D image to see major and minor bone fractures
Conclusion

- Enabling the AR ecosystem
  - How to collect, aggregate and display content
  - More accurate tracking and calibration to meet application requirement
- Content fusion
  - Delivering content using AI techniques
  - Structuring data using machine learning techniques
- Energy reduction
  - Offloading techniques
  - Efficient Algorithms
- Raises privacy concerns
Final Thoughts

- Lacks evidence and concrete examples
- Paper assumes without any knowledge of experimental analysis
- Similar paper published in 2001 as ‘Recent Advances in Augmented Reality’
- Scope of the paper is very limited and general in nature
- Cloud can be a huge part of the ecosystem
  - Provides a very generalized approach
Thank You

- Questions?