3D mobile Augmented Reality Interface for Laboratory Experiments

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Outline

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  - Virtual Reality (VR)
  - Augmented Reality (AR)
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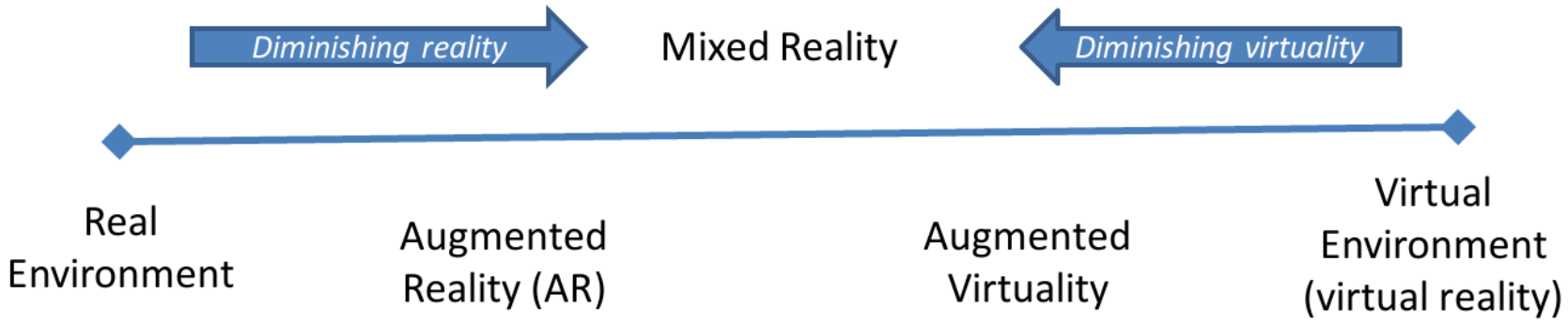
- Conclusion

INTRODUCTION

Mixed Reality Environments



$$E_{MR} = \int (R + V)$$

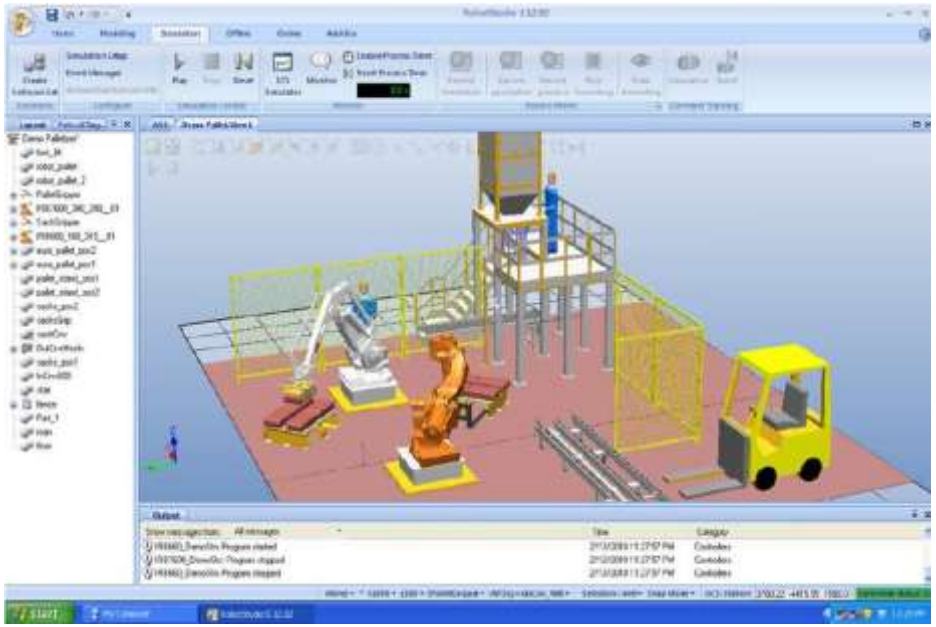
where

$$E_{MR} = \begin{cases} E_R, & \text{if } V = 0 \\ E_{AR}, & \text{if } R > V \\ E_{AV}, & \text{if } R < V \\ E_{VR}, & \text{if } R = 0 \end{cases}$$

Virtual Reality

- Computer generated environment.
- Goal: create a completely virtual environment (without real objects)
- 3D visualization
  - Non-immersive
    - Computer desktop
  - Semi-immersive
    - Flight simulator (large screen)
  - Fully immersive
    - 3D headsets or caves (rooms)

VR Examples



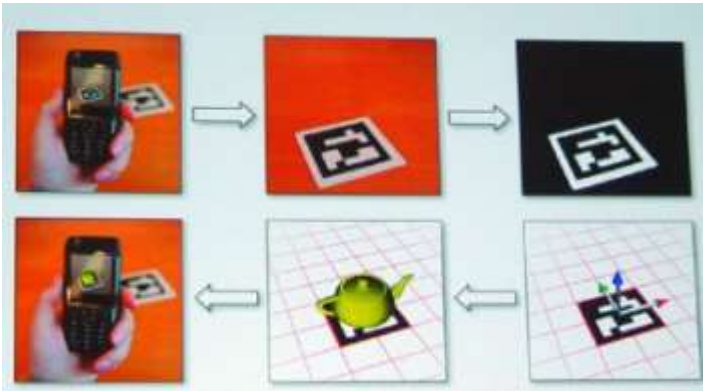
Immersive VR requires expensive components such as multiple cameras/projectors and glasses, etc

Augmented Reality

- Mixed environment (background is real, with some computer generated environment).
- Goal: integrate new virtual objects with real objects with well defined reference points/locations.
- 3D visualization
  - Layers combine different types of media:
    - Live video feed: e.g from camera/webcam or picture from camera
    - Computer generated information such as text-boxs/pop-ups.
    - Location services: real-time location information from GPS
  - Real-time integration with realism..
- Multi-media augmentations: visual, audio, tactile and haptic.

Augmented reality

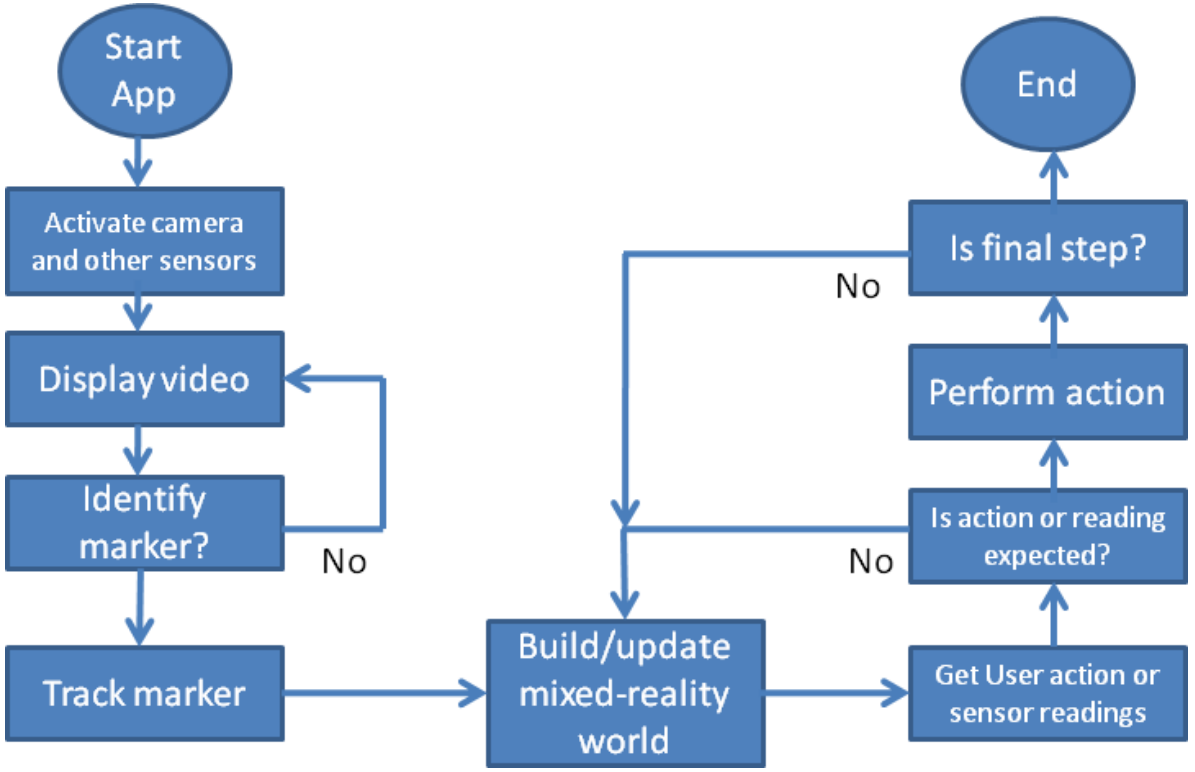
- Visualizing & interacting with virtual objects in real environment
- Tracking of objects usually via camera or webcam.



Mobile Augmented Reality (mAR)

- Smartphones and Tablets
  - Processors
    - CPU + optional GPU
  - Human Computer Interface
    - Touchscreens: tactile input/visual output
    - Speakers: Audible
    - Haptics
  - Broad range of built-in sensors: gyroscope, accelerometer, gps, pressure, humidity, etc..
- Real-time interactive input and feedback to user via touchscreen.
- Ability to sense (other) environmental conditions as additional real objects
- Limited computational power (low power) for image recognition.
- Low cost (50USD, etc)

mAR application overview



mAR apps/software

- Overlay computer generated virtual objects on real live video feeds
- Faithfully reproduce presence of virtual object in real time interactive 3D
- Semi-immersive simulation in real environment.
- Ability to use normal (arbitrary) objects as location markers
- Realistic surface textures
- Automatic zooming in 3D from any angle
- Limitations in display size, computational power

3D Mobile Augmented Reality Interface for

LABORATORY EXPERIMENTS

Objectives

- Capture and translate practical laboratory experience for digital use
  - Minimize transformations
    - Replicate step-by-step procedures
  - Maintain experience

mAR & Lab experiments

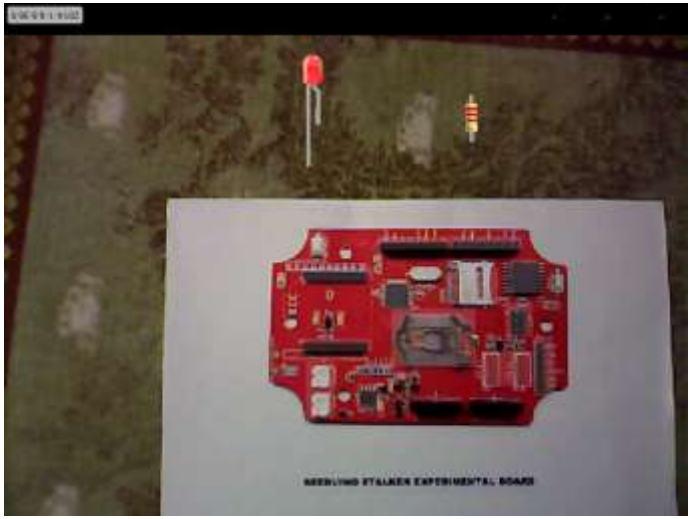
- Interface sensors
  - Multiple touch with pitch/pan on touchscreen
  - Gyroscope & accelerometer
- Complex marker for location tracking.
  - Uses photograph of real object or real object.
- Realistic graphics on virtual object
  - Real-time shadows
- Low cost devices
  - Mobiles devices or
  - < 100 euro tablets
- Stand-alone or on-line
- Simulation of procedures

Experiment 1

- Wireless sensor board
- Lab experiment
  - Connect LED and resistor to physical ports.
  - Code/programme to pulse LED at different speeds
  - Replicate the experiment: Simulate Step-by-step, showing connections & expected output

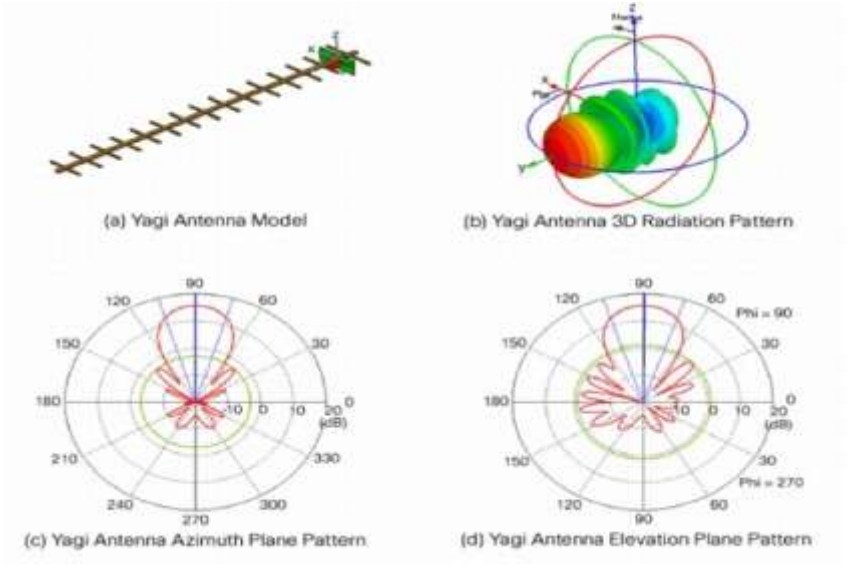
Results 1

- Overview
  - Real Video of board or photo
  - Virtual components: LED, resistors
  - Interactivity: manipulation of virtual components to created virtual circuit and pulse LED.
- Also, the AR software acts as
  - Smart interactive manual: touching a component calls up information
  - Works with photo of board or real board itself..



Experiment 2

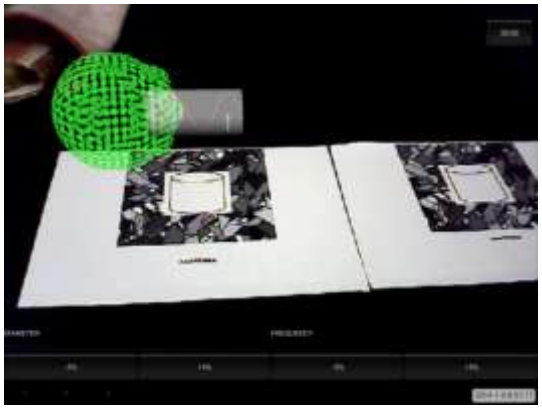
Enhancing learner perception and understanding of antennae in Communications Engineering

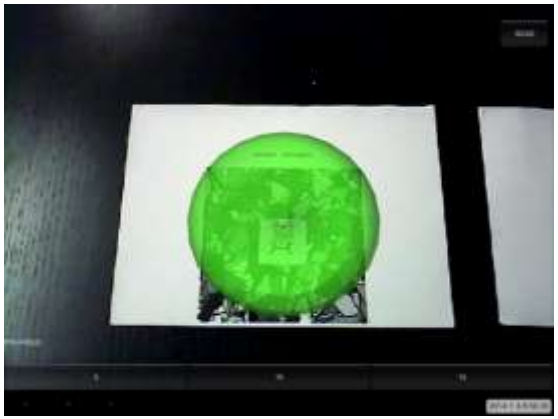


- Antenna radiation patterns better visualized in 3D
- AR app is
  - a companion tool to teaching three different antenna types.
  - Could use several QR codes on real antenna.

Results 2

Communications: Antenna radiation patterns and characterization for yagi, spyder & can antennae

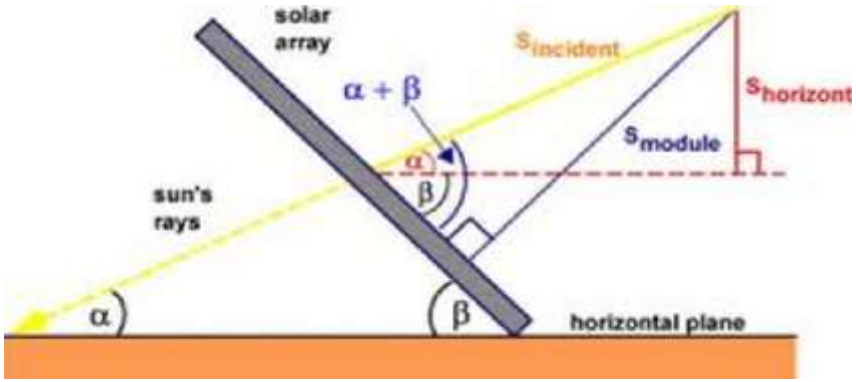




- Visualization in (3D & 2D) antenna radiation patterns.
  - Learner can observe “invisible” effects of changes in parameters
- AR app is
  - a companion-tool for teaching three different antenna types.

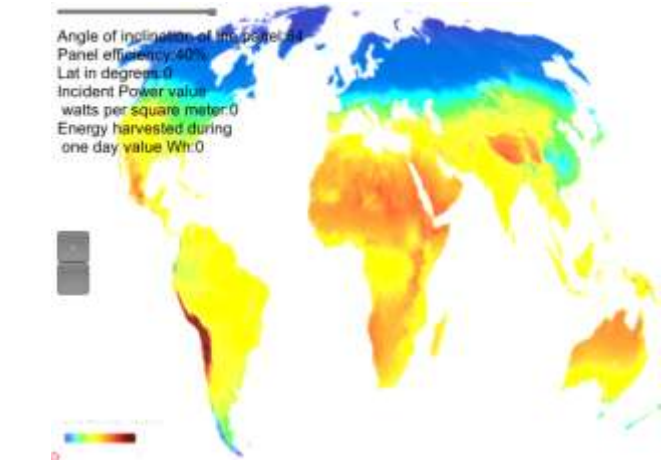
Experiment 3

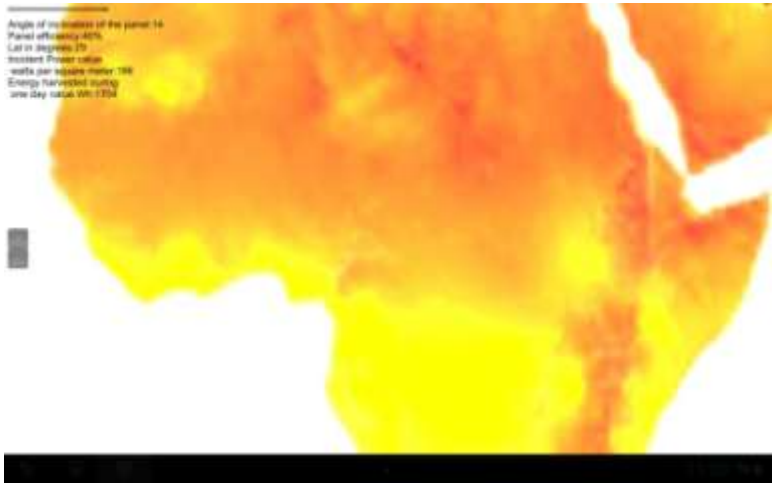
Working with solar panels, calculating energy output



- AR app will use data from INTERNET databases (EU or NASA) or a heat MAP (off-line)
  - Estimates the theoretical output potential of solar panels using GPS location information and time.
  - Can show the influence of angular orientation.

Results 3





- AR app used a solar irradiance world-map obtained from 3tier
  - Estimates the theoretical energy output of different models of solar panels at locations on the map. For different angles of inclination as determined from hardware accelerometer.

Survey on Familiarity with VR and AR in two HE institutions

Response	VR(%)	AR(%)
No	34.43	35.32
Don’t think so	10.60	08.67
Don’t know	13.91	24.67
Maybe	12.58	12.67
Yes	28.48	18.67

CONCLUSION

Overview

Innovations

- Interactive
  - Simulates/replicates experimental step-by-step procedures, including output of experiment
- Off-line use
  - Low cost mock-up
- Multi-use
  - Smart interactive manual
  - Validation of practical setup

Technical details

- Mobile Augmented Reality
  - Tablets + smart-phones with video camera
  - Low cost marker (location tracking)
- Interactive
  - Touch-screen
  - Pitch/pan
- Low cost
  - Android platform
  - Normal photograph of laboratory equipment

Summary

Strengths

- Cost effective hardware
- Simple software development
- Richer visualization of data
  - Interactivity for plots or graphs, etc..

Weaknesses

- Windowed-view
- Inherent from mobile devices
  - Poor visualization in strong ambient light
  - Limited storage capacity and battery life.
  - Single hand gestures
- Limited group use

Future work

- International network of Mixed, Augmented, Virtual Reality Laboratories:
  - Laboratory experiments
    - Joint activities
  - AR Cubicle environment using mobile devices headgear supported with IoT sensors (also for dynamic markers)
    - Training & educational use: Studying, collaborative remote visualisations
    - exploring and visiting remote locations coral reefs, sea-beds, mining and virtual tourism

Thanks

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