Augmented Reality (AR) and Virtual Reality (VR) for Science education

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Outline

- Introduction
  - Mixed Reality Environments
  - Low cost AR & VR
- AR & VR for Science education
  - Pedagogy, Digital and other approaches to learning
  - AR & VR for Science education
  - Selected examples from ICTP
- Conclusion

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INTRODUCTION

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Mixed Reality Environments

Diminishing reality → Mixed Reality ← Diminishing virtuality

Real Environment — Augmented Reality (AR) — Augmented Virtuality — Virtual Environment (virtual reality)

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- VR as a technology seeks to facilitate interactions with a computer in new (three dimensional) ways.

- In VR, the goal is to completely replace the real (physical) environment around a user with a computer generated or virtual one, where the user is still able to perceive and interact with objects using the human senses of sight, sound and touch as suitable haptic devices allow users to touch surfaces, grasp and move virtual objects as well as obtain feedback/reactions from them.

- Usually classified by immersive.

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- AR is the real-time integration of virtual (computer-generated) objects and information into a three dimensional real world environment.
- The goal in AR is to blend the virtual objects into the real world in order to enhance or compliment the real world objects and provide a semi-immersive or a window-in-the-world kind of experience
- In AR, the combination of real/virtual objects into a seamless view and management of all interactions (between real and virtual objects as well as between end-user and virtual objects) happens in real time.
- Traditionally requires place-holders (markers) in real world for placement of virtual objects. Marker-less AR use other data such as location.

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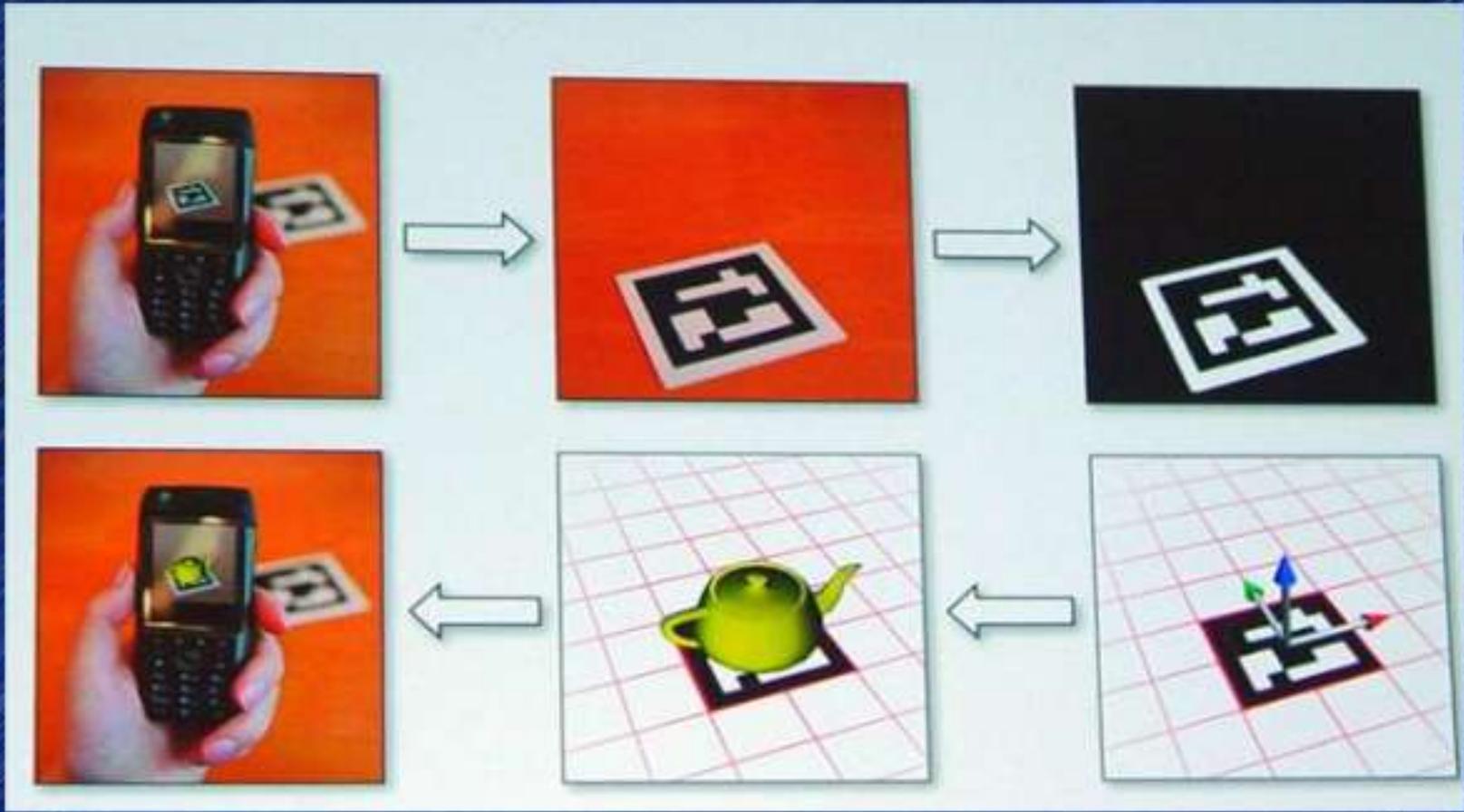
- Normal Mobile devices
  - Low cost
    - < 100 euro tablets
  - Portable size
    - **10" and less**
  - Low Power
    - Once a day charge
  - Multi-purpose computing platform
    - Extendable using apps.
  - Connectivity
    - Stand-alone or on-line

- Hardware features
  - Display Screen
    - Realistic graphics & colours
    - Real-time graphical shading/ shadows
    - Touchscreen
  - Interface sensors
    - Multiple touch with pitch/pan
    - Gyroscope & accelerometer
    - Camera
  - Performance
    - Multi-core CPU
    - Dedicated GPU

Augmented Reality (AR)

- Normal mobile devices
  - Smart-phones and tablets with camera and display.
  - Additional hardware components not required
- Other (dedicated) devices
  - Transparent glasses.
- Hardware is cost effective
  - Simplified software development.
  - In-built camera & CPU performance
    - Allows **use of "complex" markers** for placement and tracking locations of virtual objects.
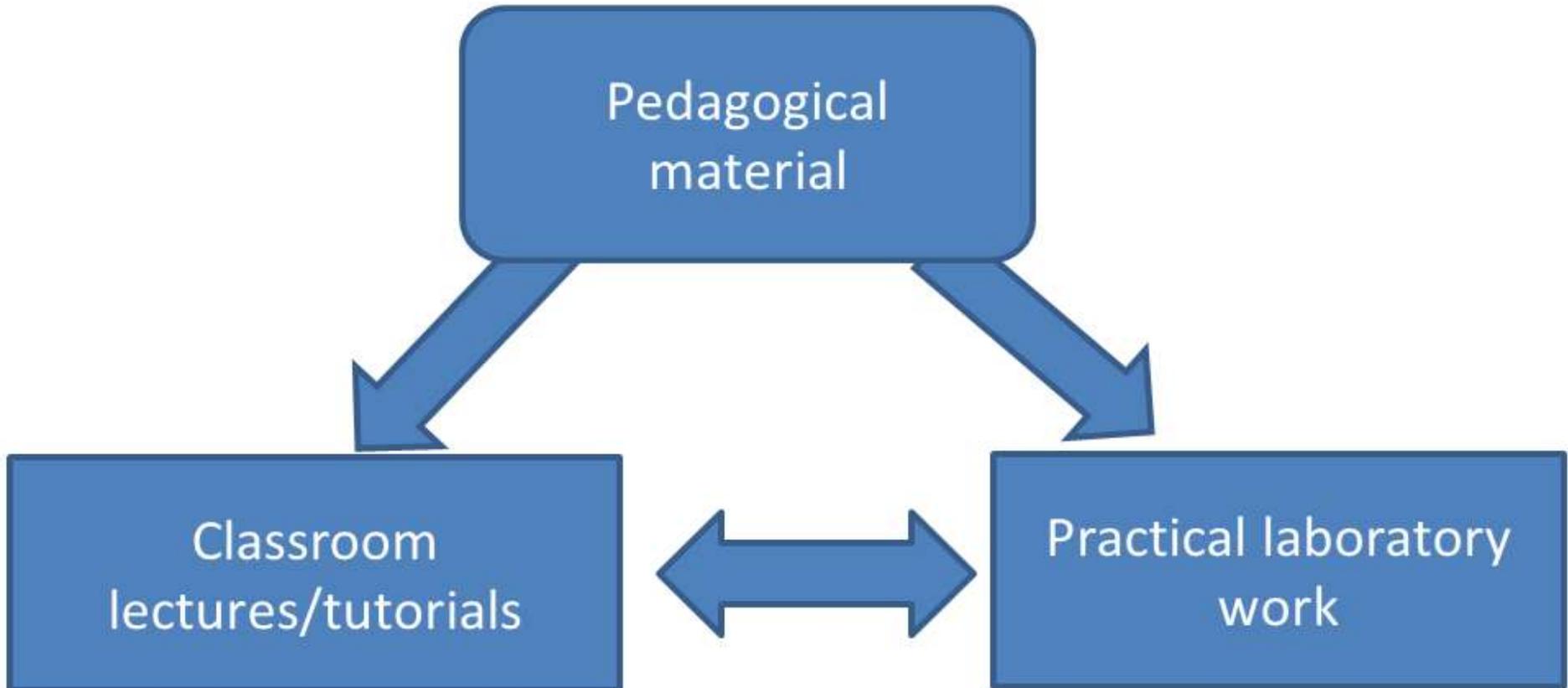
Virtual Reality(VR)

- Normal mobile devices
  - Smart phones and tablets with display plus
  - Additional hardware required (headsets)
- Other (dedicated) devices
  - Headsets, wearable devices
- Hardware (custom) is not as cost effective as AR
  - Requires development of highly specialized software.

AR & VR FOR SCIENCE EDUCATION

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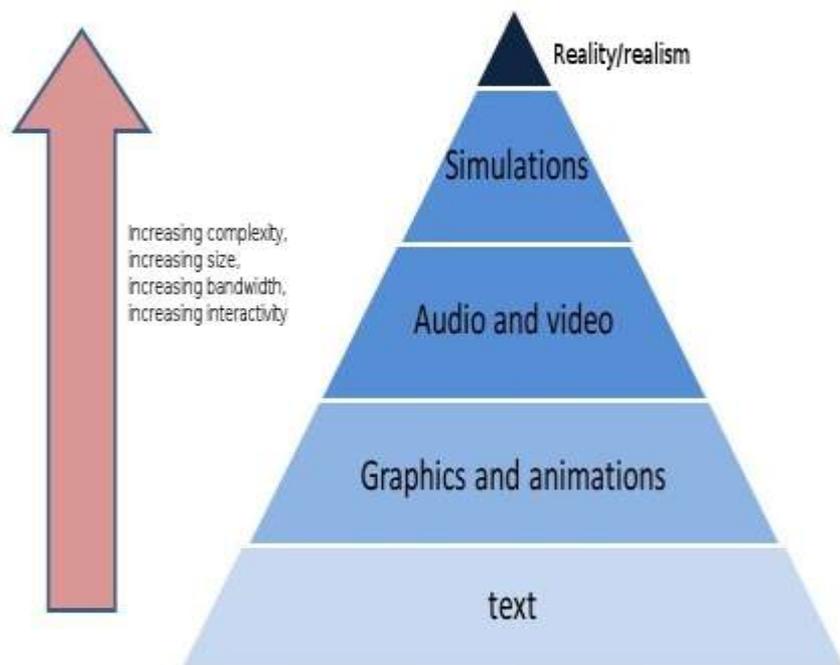
- Digital Learning
  - Many science based programmes now include some form of on-line learning component especially for theoretical aspects of pedagogy. On-line learning aspects blended in with classroom work as a way of resolving learning-teaching style mismatch. Learners have access on-line material using an any-time, any-where model (maybe not yet any device).
  - Practical (laboratory work) aspects of pedagogy still performed interactively in physical laboratories.
    - Remote Laboratories : The remote use of physical laboratories based on time-share access model.
    - Virtual Laboratories: Typically simulations that support theory aspect of pedagogy,
- Others
  - Interactive learning
    - E-books, 3D printing, Videos, IoT sensors and environment
  - Adaptive & contextual learning
    - Contextualises learning objects to geographic locations, user identity or culture , learning style, attention and feedback
  - Collaborative learning
    - Learners learn from one another, sharing and exchanging knowledge, supporting each-other towards a collective understanding and comprehension.
  - Personalised learning
    - Learning is a personal and unique experience
  - Data
    - The creation and processing of data is becoming very important and the interactive visualization of data enhances the ability to stimulate cognitive development.

Interactivity

Increasing complexity, increasing size, increasing bandwidth, increasing interactivity

Pyramid levels (top to bottom):
- Reality/realism
- Simulations
- Audio and video
- Graphics and animations
- text

- Unidirectional interactivity in learning
  - Learner is usually passive and observes.
- Emerging technologies like AR and VR are driving bi-directional interactivity
  - Learner is required to interact with learning object. Actions produce an immediate response and feedback.

- Applications are available for
  - Research & Development
    - Realistic and interactive Prototyping
    - Dynamic and interactive integration
  - Supporting Research & Education
    - Helping academics/researchers in communicating their outputs
    - Creating tools/platforms for collaborative research and learning across distances
  - Building capacity
    - Sharing know-how with other academics
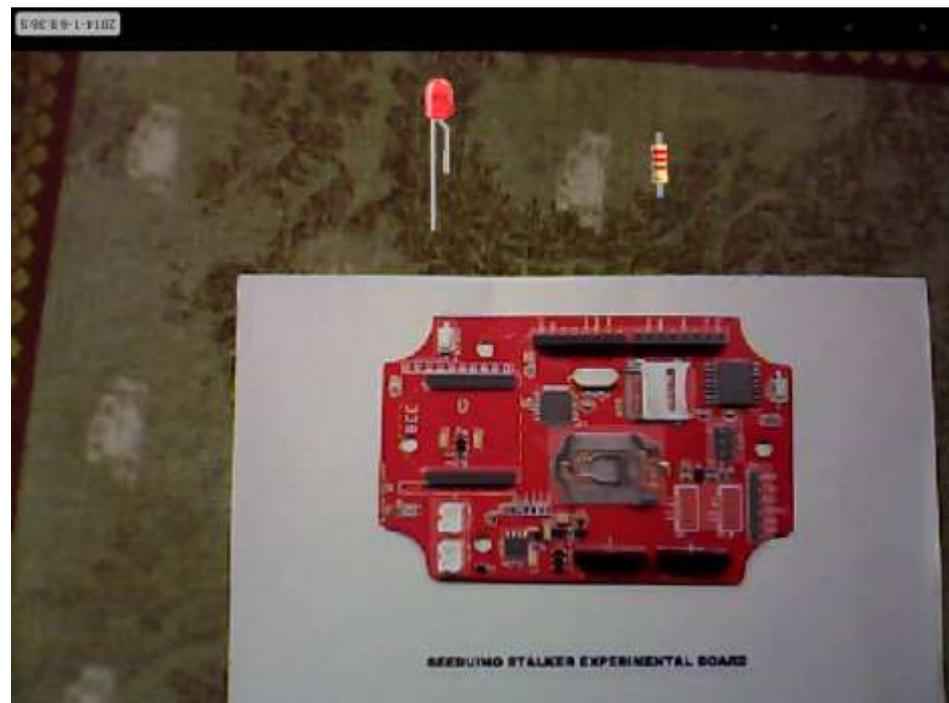 - Dissemination and Outreach
    - Bringing science to citizens events, schools, etc..

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SELECTED EXAMPLES FROM ICTP

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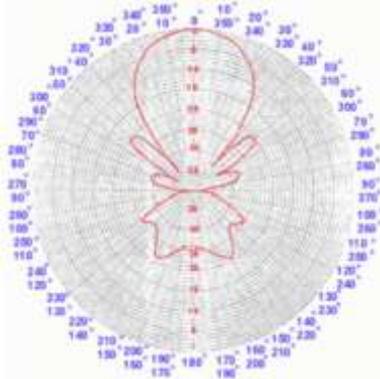Advanced Workshop on Technology for Sustainable Development: Low-Cost Tools to support Scientific Education, ICTP, Trieste, Italy

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- AR Marker
  - Paper (photo) of single PCB Seeduino board
  - Works with real board as well
  - Works off-line: without INTERNET
  - The AR software acts as
    - Smart interactive manual: touching a component calls up information
    - Replicate a full experiment: Simulate Step-by-step, showing connections & expected output.
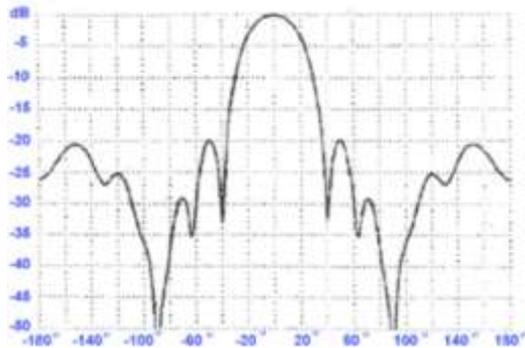   - Contextual links to on-line resources
  - http://www.youtube.com/watch?v=gsV-z9JGJC0

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From traditional implements

To mobile AR visualization

Polar plot of yagi antenna
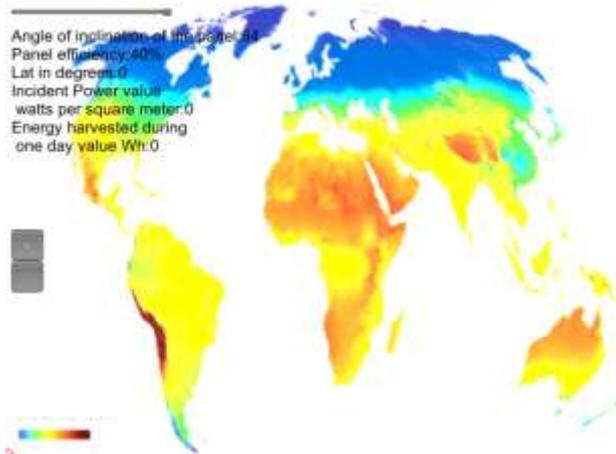
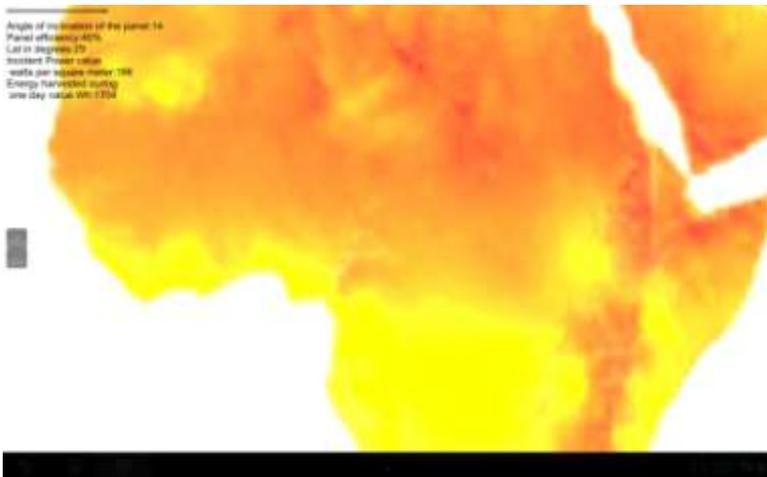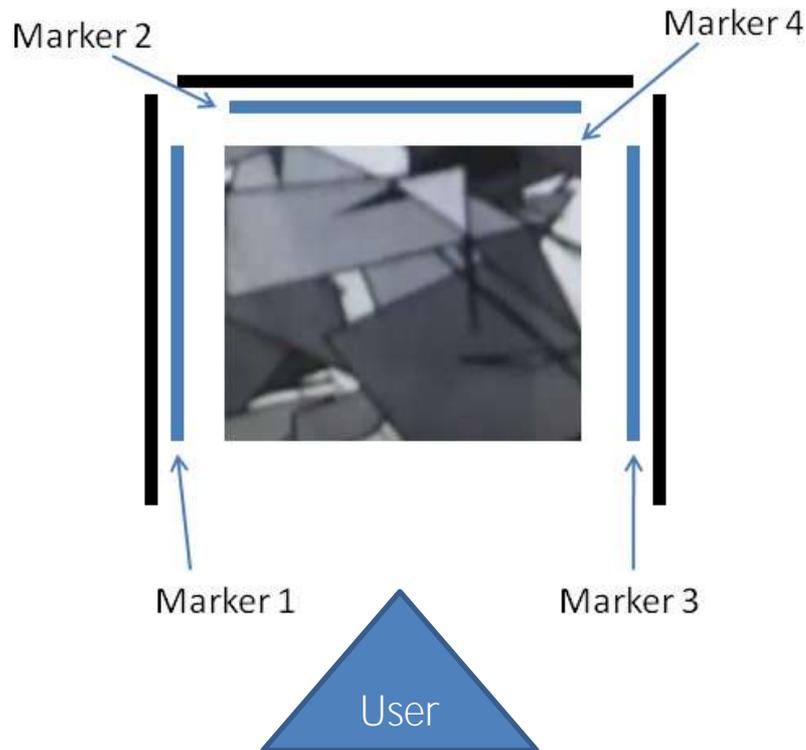Rectangular plot of yagi antenna
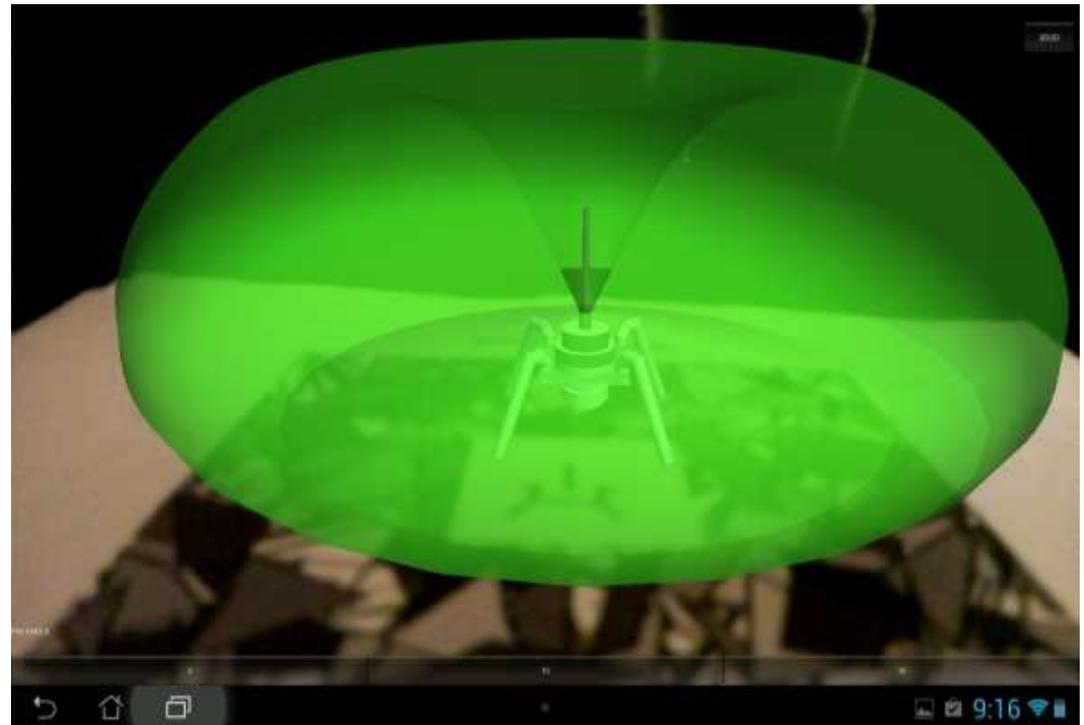
3D Spider antenna

- 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.

AR immersive cubicle

180° horizontal by 3 markers on walls
and 90° vertical by marker on floor

CONCLUSION

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Strengths

- Cost effective hardware
- Software development for AR is simple, VR harder. Using suitable libraries is recommended
- Richer interactive visualization of data and outputs.

Weaknesses

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

Future work

- AR &VR for Science Education: interactive, personalized and collaborative learning
  - 360° visualizations using mobile headgear for studying, exploring, observing and visiting remote objects, locations coral reefs, sea-beds, mining and virtual tourism
  - AR Cubicle environment using mobile devices headgear supported with IoT sensors (dynamic marker)
  - Remote collaborative visualizations
  - Dynamic streaming and fragmentation of data
  - Near Real-time interaction with data from IoT sensors

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