# Application of Sensors in Augmented Reality based Interactive Learning Environments

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*Abstract-* **Context awareness, user friendliness, and interactivity are very important and powerful concepts in building useful teaching/learning environments for the benefit of mankind. Advancements in technology are enabling us to look at new use cases in the methods of teaching, information sharing, knowledge dissemination, and self-learning. Learning environments are not only for teaching things to people, but also for providing more information to them on any subject that they may require from time to time.**

**User friendliness can be enhanced with clever use of sensors to give hands free interactivity with the devices/gadgets. Context aware applications require sensors to get the context information. Mobile devices like smart phones and tablets today come with a hand full of sensors mounted on them which include one or two cameras, a microphone, a touch screen, an accelerometer to sense motion, and in addition have GPS and digital compass to provide location information to applications requiring these sensory inputs. The computational power packed in the processors used in these devices/gadgets including special support for graphics processing, the near general purpose computer like operating system environments, and the quality of cameras available, are all enabling application developers to map some serious computer vision based applications on today's mobile devices. This reality has encouraged us to get into development of Augmented Reality (AR) based interactive learning environments on mobile devices, leading to our development of a software framework for AR applications development and also development of an AR book and an AR board.**

**AR has been called the eighth mass medium, after print, recordings, cinema, radio, television, Internet and mobile phones. There is ample scope for enhancing the learning/teaching experiences of the users with AR based learning environments. AR makes learning more effective and an enjoyable experience by providing more realistic information with the use of 3D graphics and animated models.**

***Keywords—Augmented Reality, AR, context awareness, AR learning***

## I. INTRODUCTION

### *A. Background:*

Context Aware Computing and Augmented Reality (AR) applications will be prominent among the top few technology application trends in the second decade of the twenty-first century [11].

The enabling forces behind this trend are:

- Increasing power of computation on affordable hardware platforms
- Maturity of support technologies for context awareness including sensors, image processing and graphics
- Rapid developments in Wireless/mobile communications fabric (broadband, standards, interfaces, networks, …)
- Raise in the basic expectations of performance and perception standards of end users of technology

In spite of these enabling forces, there are a few challenges that a developer has to face in developing these advanced applications on mobile platforms:

- Lack of mature application software development tools/environments for building AR applications on various hardware and software platforms
- Poor quality (accuracy, range, and other characteristics) of some of the sensors on commercial mobile devices
- Growing number of hardware and OS platforms (typical to embedded systems development scenario)

Opportunities:

- A vast scope for new use-cases in application areas like interactive learning, interactive gaming, tourism, and advertisement
- Scope for developing light weight algorithms for context evaluation, and pattern recognition
- 3D content development for more effective and useful AR applications
- Scope for new technical/business collaborations to meet the technology specialization demands
- Building applications that can benefit the masses (common man)

In order to address the challenges and take up the opportunities, an R&D lab named "Mobile Applications Research and Systems (MARS) Lab" has been established in CDAC, Knowledge Park, Bangalore represented by the authors.

*B. Mobile Context Aware Augmented Reality Applications:*

The convergence of three concepts of mobile computing, context awareness, and AR is happening naturally in the applications space these days.

The following are some of the Context Aware AR applications being explored by the team:

- Learning environments / Innovative Teaching Aids: including self-learning, remote assistance using mobile technology, story books for children, and applications to help differently abled people (Autism, Blind, Dumb and Deaf)
- Advertisement: Marker based AR technology used for presenting virtual products to the customers
- Travel and Tourism: Location based services using AR technology

*C. Learning Environments:*

Learning can happen in either formal or informal ways. Trends in both modes of learning show that people expect to be able to work, learn, and study whenever and wherever they want. It is intended to make our solutions compatible with SCORM (Scalable Content Object Reference Model) LMS (Learning Management System) systems.

The following are some characteristic advantages of a learning environment using Mobile Communication and context aware AR technologies:

- Make learning an interactive and enjoyable experience
- Provide customized teaching/ information sharing, freeing the user from the information glut provided by the internet and other information sources
- Faster learning through the use of 3D animated models, and audio augmentations to explain/teach some concepts and to share more realistic information/content

*D. Organization of content in this paper:*

To start with this paper gives a perspective on Augmented Reality (AR) followed by a brief explanation on the concept of Context. An overview of a learning environment using context aware mobile assisted AR technologies is given, followed by AR board application using an AR software framework both developed by the authors, and then conclusions.

## II. CONCEPT OF CONTEXT AWARE AUGMENTED REALITY

*A. Augmented Reality Basics*

There are many related definitions and interpretations of the term "Augmented Reality (AR)", but the basic commonality in all definitions is that there is some synthetic (computer generated) content augmented to the real-world content perceived by an observer (human being), in real-time. We stick to this basic concept while presenting our understanding of the concept of augmented reality. We also realize that the comprehension of "AR" is generally restricted to the visual perception domain – Synthetic objects (2D/3D) augmented to the real world views in real-time.

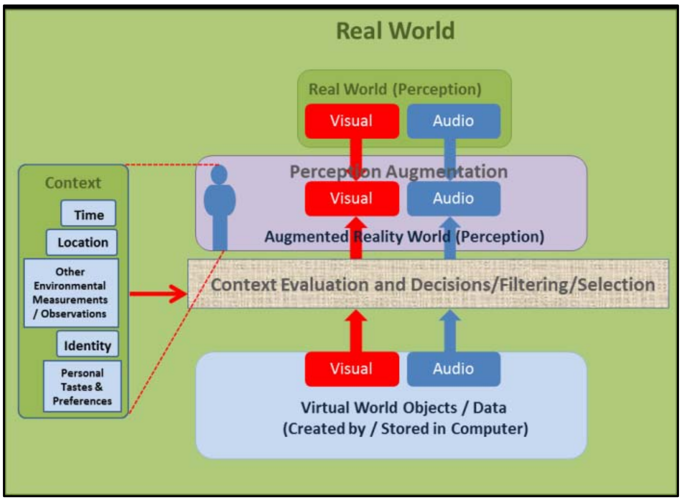


**Figure 1: Augmented Reality Domains**

Figure 1 gives our concept diagram of Context Aware AR. The observer perceives an AR environment formed by the augmentation of virtual perception entities to corresponding real-world entities, in real-time.

Sensory gadgets like camera and microphone capture the real-world perception in real-time and provide the real-world inputs to the AR system. In addition to these inputs the Context Aware AR system will typically get inputs from sensors like accelerometers, compass, GPS, temperature and light intensity sensors etc. that are required to get the context information. A video/graphics display device is required in the AR system for the observer to perceive/view the visual AR content.

The virtual content to be augmented is decided by a context evaluation/filtering stage, that gets the context information relevant to the person (perceiver) from sensor inputs in the real-world, location information, and personal preferences of the person.

*B. Context*

When we are dealing with the subject of Context Aware Augmented Reality, the term "Context" determines the content that gets augmented to reality. Figure 2 depicts our understanding of the concept of context. As shown in this figure, we have the mobile/handheld device that has sensors to get the context information.

Determining the context can be a multi-level process. The first level context information comes from various sensors attached directly/indirectly to the mobile device. Environmental measurements include temperature, humidity, light intensity, sound energy, etc. Location information comes from GPS interface, but can also come from other triangulation methods with distance measurement techniques. In addition there are useful devices like the compass and accelerometer that give the direction, motion and orientation of the person. Time is another context input useful in some applications.

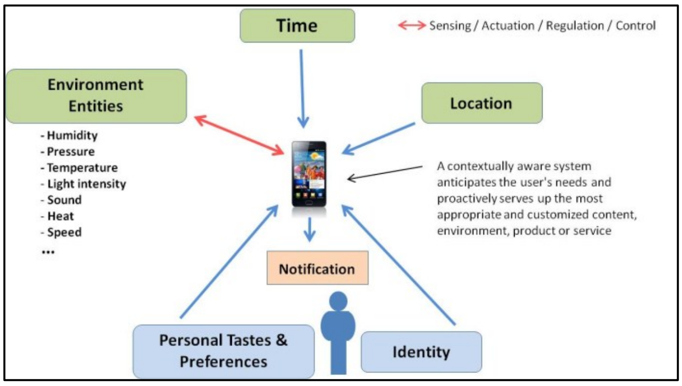

**Figure 2: Types of Context**

The second level context is derived based on the inputs from the sensors after some reasoning and matching/evaluating with the personal tastes and preferences of the person.

Based on the context, the context aware system responds in an appropriate way to the user. The response could be as simple as notifying the person about an event. Personal identity is also used by some context aware systems.

## III. Learning Framework with AR

As we introduce new technologies like augmented reality into learning ecosystem as given in Figure 3 below, interesting and more useful usage patterns/application scenarios will evolve. Implementation of these applications will require new software development frameworks. This requirement is being addressed by the authors with the development of a software development framework in their lab.

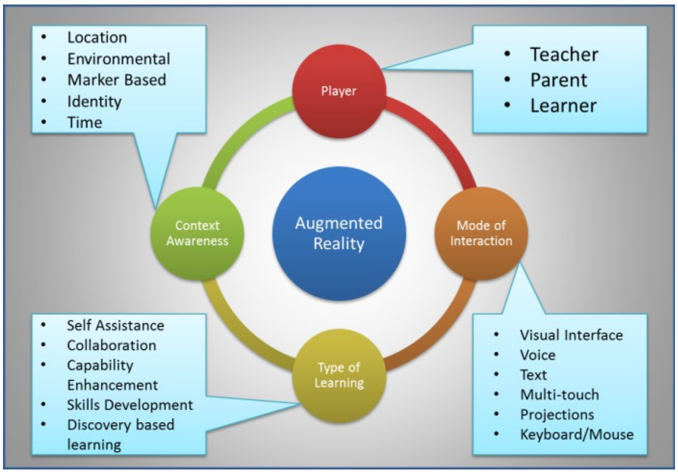

**Figure 3: AR Learning Ecosystem**

The essence of this diagram is the merging of 4 important entities: – Augmented Reality user, mode of interaction, various types of learning and context awareness under the ecosystem of augmented reality.

**Ecosystem Blocks:**
Each block of the diagram is being described as follows –
*Players* – The players are the users of the framework; these are teachers, students, developers and 3D content generators.
*Mode of interaction* – The mode of interaction is the various modes of interaction of a user to the environment and augmented reality inputs. The modes of interactions are mobile centric like touch, visual, voice and text etc. or keyboard/mouse.
*Types of learning* – The various ways of learning are being described here. Self-learning is an example of assistive help based learning.
*Context Aware* – The context aware applications are the applications, which obtain context of the user based on different inputs from different sensors. Based on this context, the application decides which content to provide.

### *A. AR book - use-case:*

Figure 4 shows the implementation of the AR book application. An AR book is a special book instrumented with picture markers. When these markers are scanned using a mobile device, the corresponding marker associated content is fetched from the remote database. This content is then superimposed over the marker and shown in the device window.

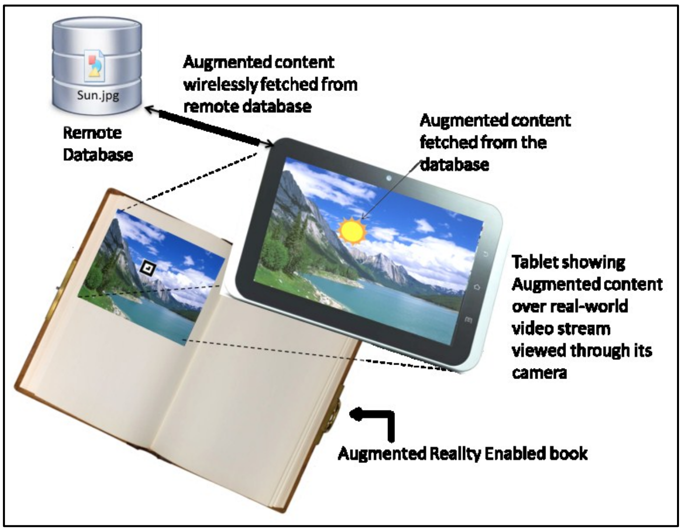

**Figure 4: AR use-case**

With reference to Figure 4, the tablet scans the picture in the book. Once the picture is successfully scanned and the marker is recognized, the image associated with the marker is fetched from the database and superimposed on the original image.

*B. Framework Architecture:*

The use-case mentioned in previous section can be realized using the framework shown in Figure 5. The framework architecture is majorly divided into two parts, tools and AR engine. The Authoring tool and AR player are the tools provided to the user for creating AR applications. The authoring tool is used to define the markers to create context, select and associate content to the context provided by the markers by creating an appropriate content association table that will be saved along with the content.

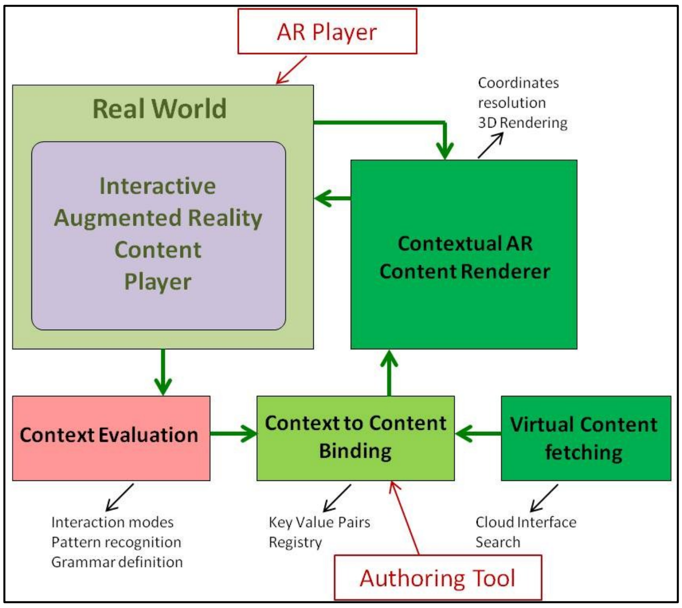


**Figure 5: Software framework architecture for realizing AR Learning**

Authoring tool needs to interface with the database to fetch content and store the content association table back in the database. The task of AR player is to find the context in the field of view by applying pattern recognition techniques to the output of camera sensor and find the predefined markers which are instrumented in the real world. Once the context is evaluated using content association table, corresponding content is fetched from the database and this content is rendered with the real world view on the display. An AR board application has been implemented using the framework components.

*C. Augmented Reality based Board:*

This application finds its use in classroom teaching or collaborative learning by enabling the teacher to enhance his/her presentation of content by providing a projected AR environment. The AR environment allows the teacher to use markers for projecting 2D/3D content on the markers. The markers can include line patterns, characters, geometric shapes, colors etc. on the board to provide the context to the AR board application. The concept diagram of AR board is given in Figure 6.

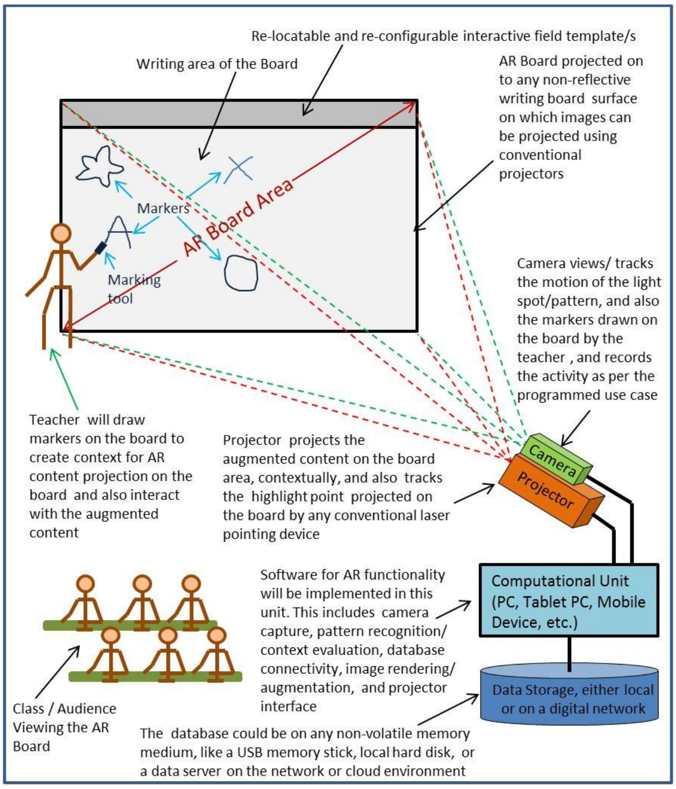


**Figure 6: Concept diagram of AR board application**

The architecture diagram of the AR board application is shown in Figure 7. The application has 2 modules in it – *the class session creation module, and the class presentation module.*

The *Class session creation module,* defines the markers to be used and the content that must be associated with the marker, for a particular topic. The markers can be reused for different topics. This marker-content association information, along with the marker template and associated content for a particular topic, are stored into a database repository.

The *Class presentation module* implements the AR board functionality. The camera scans the markers shown on the board, and gives the feed to the Recognition engine. The Recognition engine detects the markers from the camera feed and extracts the position information of the markers. The Association evaluation engine uses the marker information to obtain the corresponding associated content from the database repository. The associated data fetched, is stored into a local cache. The AR player takes the position information from the recognition engine and the content to be augmented from the local cache through association engine and projects it over the board at the marker location.

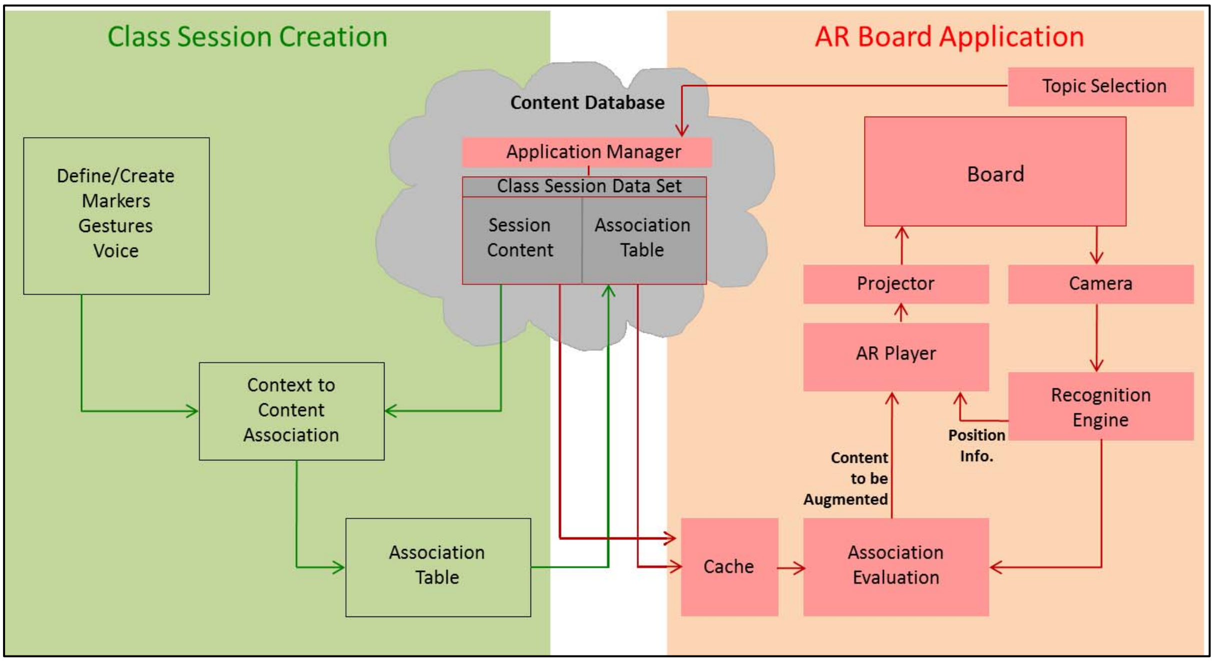


**Figure 7: Architecture diagram of AR Board framework**

## IV. Conclusions

Sensors are extensively used to derive the context in Context Aware AR applications. Sufficient number of them are available on mobile devices today to development such applications.

There is big opportunity available to develop new applications/services. Context aware learning environments will benefit with the use of mobile, AR, and internet technologies.

Augmented reality has been called the eighth mass medium, after print, recordings, cinema, radio, television, Internet and mobile phones. By reaching out to media companies, the industry, which was a collection of smartphone apps generating less than $2 million in 2010, is on the verge of becoming a real business worth perhaps $1.5 billion in 2015 [11]

MARS lab is conducting research activities in tune with the growing industry demands. There is a need to develop software development framework for developing advanced AR learning applications. An AR software framework and applications like the AR board presented in this paper are being developed in MARS lab.

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