



## Spatial Computing application and opportunities in Emerging Markets of India

2578

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### Abstract—

This research paper is written on the works published by other authors about spatial computing. The main objective of this paper is to summarize those work and compare those work with the real time scenario of current economic environments of emerging markets in India and suggest several use cases in which spatial computing could be useful.

**Keywords**—Spatial Computing, Graphical Processing Unit, Augmented Reality, Virtual Reality, Mixed Reality, GDP (Gross Domestic Product)

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### I. INTRODUCTION ON SPATIAL COMPUTING WITH REGARD TO INDIAN ECOSYSTEM

The term spatial computing was first used by MIT Media Lab alumni Simon Greenwold in his very futuristic thesis in 2003. In his thesis he defined spatial computing as the virtualization of activities and interactions between machines, peoples, objects and environments in which they take place. In his thesis he discussed how spatial computing enables coequal collaboration between humans and machines, but it also enhances each individually.

In the last twenty year we had seen substantial growth in the usage of mobile devices. This has led to an increase in production of hardware that are easy to use and power efficient.

Today, technologies had evolved to render three-dimensional models in mobile phones which has led to increase in adoption of newer concepts like Augmented Reality and Virtual Reality with same promise of smartphones. Specific devices like headsets and kits are made to increase the accessibility of these new technologies.

In the recent years India had seen a technological boom in consumer markets and during the pandemic we had seen a wider adoption of newer technologies by the Indian consumers. These technologies promises an array of new transformative capabilities in emerging markets of India. As the research and cooperation between companies increase we will see these products to reach wider audience.

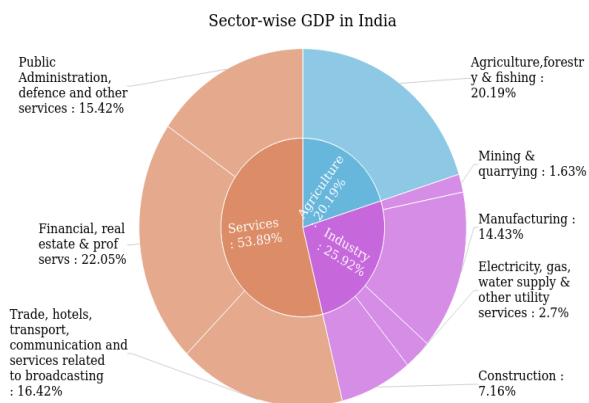
In this Paper our goal is to showcase the potential markets which could benefit from Spatial Computing. We do this by showcasing current economic scenario of Formal Sectors of India in section 2. In, section 3 we will provide overview of recent investments to increase adoption of spatial computing. Finally, In section 4 we will suggest several applications in which spatial computing could be useful.



## II. ECONOMIC SCENARIO OF FORMAL SECTORS IN INDIA

### A. Overview of Formal Sectors in India

Indian formal sector has been primarily divided into Services, Agriculture and Industry out of which service sector is the biggest employer and has captures largest chunk of GDP after which industrial sector is the second largest contributor of India’s GDP and the third largest is Agriculture Sector which is the traditional sector of India.



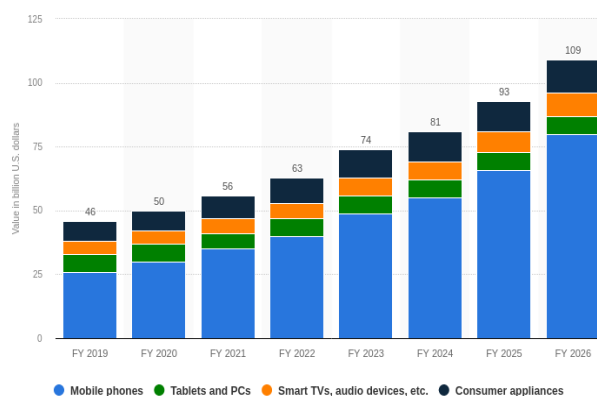
According to graph published by Statics times. Service sector holds biggest chunk of Indian economy and contributes to 53.89% which is more than half of the GDP out of which 15.42% contributed by Public Administration, defence and Other services; 22.05% contributed by Financial, real estate and Professional services; 16.42% contributed by Trade, hotels, transport, communication and services related to broadcasting. Industrial Sector which holds second largest chunk in GDP which consists Mining and quarrying at 1.63%; Manufacturing at 14.43%; Electricity, gas, water supply and other utility services at 2.7%; Construction at 7.16%. Agriculture sector which is the traditional backbone of Indian economy consists of various services which contributes to 20.19% of GDP.

India is the fastest growing emerging markets with the second largest consumer market in the world. India ranks at 28 in the cheapest data as per cable.co.uk. 48% of Indians use internet daily with some or another form.

### B. Consumer Market and Accessibility to Supplementary products

Indian Consumer market is broadly segregated into two categories urban and rural markets. These markets consists of huge middle class, relatively large affluent class and a small economically disadvantaged class. The growth of

market is primarily driven by a favourable population composition and increasing disposable income. Appliances and consumer electronic market estimated at 75,000 crores and is expected to more than double to reach 1.48 lakh crores.



The Above Stacked bar graph represents different market size of key electronic products from financial year 2019 to 2020, with forecasts up to financial year 2026.

On September 2019, major mobile telecom operator Reliance Jio had launched it’s broadband services which use fiber optics cable instead of copper cable used by telephones. Broadband services had seen a significant rise in Internet speed after using fiber cables. During their launch event they had showcased Reliance Jio Virtual Reality games that can be easily accessible from their jio store.

The Indian Augmented Reality and Virtual Reality market is estimated around 14000 crores in Fiscal Year 2020 and is expected to grow at a CAGR of 38.29% until Fiscal Year 2027. The availability of Virtual Reality devices, growing adoption of head mounted display during Covid-19 Pandemic had made India a best market for technological innovations like Spatial Computing.

## III. RECENT INVESTMENTS IN TECHNOLOGIES FOR ADOPTION OF SPATIAL COMPUTING

In August 2021, Thane-based AjnaLens launched enterprise-grade (AR) glasses with a software suite. Three months later, Carzso, had announced that it will offer 360-degree views of its virtual car to customers.

In 2020, Reliance jio showcased a mixed reality (MR) glasses called Jio Glass, which can be used to create 3D virtual classrooms and holographic models. Jio is working to create more usability for their headsets that can be used in other industries too.

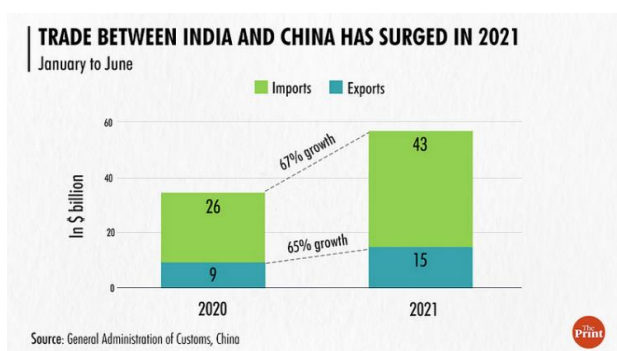


These are the good examples that augmented and virtual reality wearables are gaining momentum in Indian markets. Their adoption is currently limited to few industries but is expected to improve further in future.

The enterprise segment accounted for 72% of Augmented Reality and Virtual Reality market in 2020, according to the Research and Market reports published by mint in September 2021.

#### A. Hardware and Logistics

India had invested hugely in semiconductor markets to decrease its dependency on imports of hardware from other markets. India import from China has increased during the middle of pandemic as per the graph published on 9 August 2021 by “The Print”.



This data had alarmed government of India to increase investments in hardware manufacturing.

On 2021 government of India has announced several benefits and investment opportunities for semiconductor and hardware companies who will invest in India which had generated a good interest from global companies. The Government of India had launched a program called Semicon India Programme on December 15, 2021 with an outlay of 76,000 crores seeking support on the development of semiconductor and display manufacturing in India.

#### B. Software

India has become a global hub for outsourcing software services. In the last two decades India has emerged as an Information Technology (IT) powerhouse. The swift advancement within the IT industry and liberalisation policies by reducing the trade barriers and eliminating import duties on technology products by the Indian Government had proven instrumental in development of IT industry. Government Initiatives like Software Technologies Park, Export Oriented Units, Special Economic Zones and Foreign Direct Investment

have helped in promoting newer technologies. The Majority of global corporations are sourcing Information Technology Enabled Services (IT-TES), accounting for approximately 55% of global sourcing market estimated around 20 lakh crores in 2019-2020. The market size of IT industry has grown about 189% if we compare 2008-2009 to 2019-2020 and is estimate to grow to become 26 lakh crore market. India digitally skilled pool has grown over the period and accounted for 75%. The rollout of different technologies like big data analytics, fifth-generation communication technology, cloud computing and the Internet of Things will create an expansion of IT fields in India.

The Atmanirbhar Bharat initiative has been bringing wave of changes in IT sector. Many existing big corporations has taken big steps towards making India self-sufficient in technological advancements. India is expected to have digital economy of One trillion dollar by 2025.

Greg Sullivan, Director, Mixed Reality at Microsoft has quoted “mint” in their article titled “Will 2022 be the year of AR/VR in wearables space?” “The mixed reality space has been evolving over a number of years and we believe that it will continue to do so as headsets increasingly become more immersive, more affordable and available in more socially acceptable form factors”

The total AR/VR industry of India in 2020 was estimated at 140 crores and it is expected to grow at a Compound Annual Growth Rate (CAGR) of around of 38.29% by 2027. Total Industry has been divided into different segments like head-mounted devices, handheld device applications, smart glasses and head-up displays.

The big hype around the new platform launched by facebook by changing his name from facebook to meta will provide a big push to the technology.

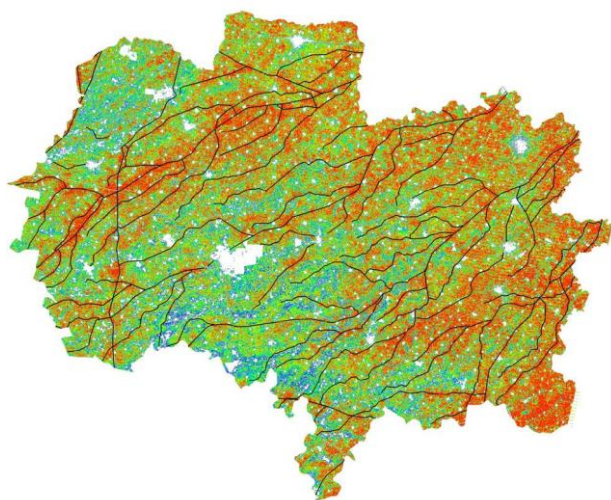
#### IV. SEVERAL APPLICATIONS IN WHICH SPATIAL COMPUTING COULD BE USEFUL

##### A. Working with quantitative and qualitative data in cartographic studies

Spatial Computing can be used to support computational representation analysis of maps and other geographical data. Geographical Information System can understand a large number of map projections used by geographer which could help in fusing map data from various sources. Geographical Information System when

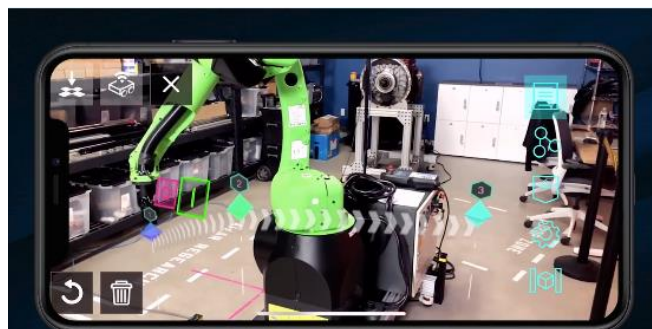


paired with different satellite images could understand more accurate representations of earth. Geographic Information System stores, analyses, manages and visualizes spatial data and map layers. For example: Geographic Information System cartographers use satellite and remote-sensing data to explore patterns and relationships. Such digital data offers estimates of average wheat yields in the Punjab region of India between 2000 to 2008. Red shows areas with highest yields, blue shows lowest yields, and white are non-wheat areas (e.g. towns). Black lines show the location of major surface water canals, where yields tend to be higher.



### B. Reprogramming Robots in real-time

Industrial robots have been programmed using teaching pendants, whereas offline programming methods are getting increasingly popular in recent years. Programming robots is not a straightforward task and can take hours and days. Augmented Reality shows a potential in robot programming by using smartphones. Augmented Reality allows the operator to preview the robot's intended motion, and the task is transferred to the real robot if the operation is the same as expected. AR is used for trajectory interaction, and to compare the programming method with kinesthetic method review system is used. It has been found out that it takes less teaching time using the proposed Augmented Reality robotic interface than performing kinesthetic teaching. Specifying more complex paths example sine curves are much easier in Augmented Reality interface. When Augmented Reality is mixed with remote access one can program robots from anyplace through internet.

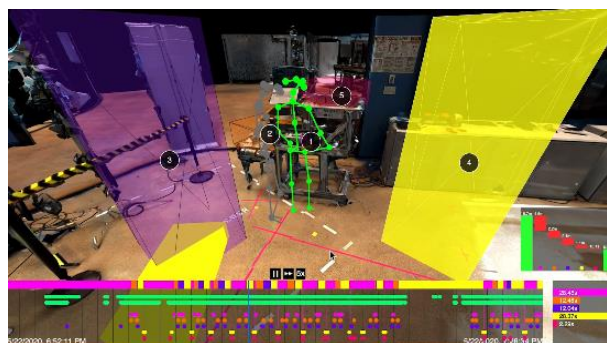


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### C. Spatial Analytics for workforce productivity

Spatial Computing can be used for motion study using sensors to study recognition of steps required for getting a work done. We can digitize the entire settings such as factory. These settings would be really helpful due to the specialized environment of mixed reality. This could really help to implement the various principles of F.W.Taylor. This machine analytics is the futuristic version of works of Frank and Lillian Gilbreth motion study research. These analyses could help to recognize the bottleneck in employee workflow and factory settings.

Companies like Volvo and Audi are using Spatial computing to provide real-time animations as a manual to decrease the time taken for learning the job. It has been found that people who learn to assemble parts from manual take 25% more time than people who are learning at real time using Spatial Computing.



### D. A Biologically inspired Spatial Computer that learns to see and act.

In the research paper published by Cambridge they had tried to simulate Vision and motor control as sensors to simulate human visual system. In their research they provided a different perspective on the human visual system that suggests placing a greater emphasis on structures that can learn representations, rather than on designing the representations. They had developed an architecture for learning to see and act that is based on engineered emergence. They

had proposed an approach in which solution is engineered by connecting learning components into a spatial computer. Perception and actuation procedures have been learned within the spatial computer based upon the location where information converges within the spatial computer and the perceptual patterns of local components within the computer. These paper were published with the early ideas some of the interesting outcome had been observed.

The Research includes a Robotic bug with synthesized vision from an overhead camera and four actuation spaces corresponding to turn left, turn right, move forward and move backward has been programmed. The picture of bug has been given below.

In this research the platform consists of two robotic bugs that have a small number of control actions. They can move forward and backward and can turn left and right for some duration of time. The legs slip on the surface injecting a noise component into the actuation procedures forcing a tight perception/action control loop. The image represented below has Blue objects as barriers and green objects as targets.



The approaches used in decision making experiments are Cached event-string automata, String-stitching, Intrinsic motivation driven by surprise and string hinge spreading activation.



*E. Spatial Computing to build topological space embedding musical relationship in their neighborhood relationships*

In the paper published by LACL/Université Paris Est Creteil author Louis Bigo, Jean-Louis Giavitto and Antoine Spicher propose two studies of paradigmatic theoretical music problems from a spatial computing perspective. Their research paper was aimed at presenting the first results in the application of the spatial computing paradigm to musical theory problems. The two problems presented by them by illustrating the diatonic scale and the classification of the All Interval Series.

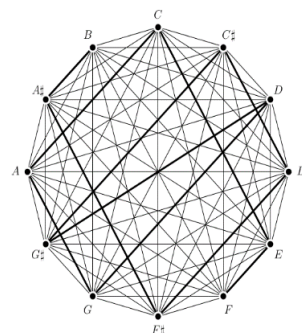


Fig. 6. Spatial representation of Alban Berg's AIS (in bold in the complete graph).

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