# SMART HOME ENVIRONMENT - A BIBLIOMETRIC REVIEW

Priti Puri and Yatin Jog

# REVIEW ARTICLE

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| ARTICLE INFO | ABSTRACT |
|---|---|
| | In today's era of 21st century the world witnessing a tangential shift in technology and innovation in a short span of time. Various innovations in the area of computing, processing and analytics are happening today. However, today the buzzword "Smart homes and IoT" is most popular among the companies, universities, research scholars and so on. With the advent of emerging technologies and innovations like big data analytics, booming telecom sector, increasing broadband connectivity and improved processing capability of various devices and sensors, the idea of having a smart home which was looking impossible till the very recent time now seems to be feasible and possible. We have conducted Bibliometric review of the research papers and come up with few metrics to understand the research done in smart home environment. Based on this one could get clues on the area to be focused for further work. The analysis is with limitation that entire content of the research papers have not been analyzed. All the metrics are presented in graphical and tabular format. |

## INTRODUCTION

Smart homes today is derived from amalgamation of Internet of Everything. The way majority of our gadgets are networked together gives us a consistent control over all sub-parts of our home and the sky is the limit from there. Mobiles have changed the way we consider collaborating with the innovation in our homes and it's made a longing zest for constant association and control that was once inconceivable .Innovative thoughts are applied to every aspect revolving around a smart home to evolve it further. From point product providing single service to multi proposition systems and data driven services smart home industry has evolved to provide comfort, energy and money saving, security and luxury to users. Thus innovation, technology and customer expectation can be said as the drivers of home automation system. Today the concept of smart home has taken a leap ahead from merely being a concept to a solution which is practically implemented.

The primary focus of this paper is to measure some of the parameters of the research already done in the area of smart home. The database used for the study is Scopus, EBSCO, EMIS (Emerging Markets Information Service), Emerald Insight database along with free resources like google scholar.

These resources form a strong platform to harness most of the research being done worldwide.

In this paper we have basically tried to look at the quantum of research done in the different countries, universities, What key word have been used over the years and which are most prominent, how many authors are contributing to this work, which are the top journals that are publishing these articles and how many papers are being published year on year. A total of 75 research papers were used for the bibliometric analysis.

## METHODOLOGY

To conduct the study we took inputs from Scopus, EBSCO, EMIS (Emerging Markets Information Service), Emerald Insight database along with free resources like google scholar .Journal articles along with Conference papers were selected to identify the diverse nature of the research done so far. The primary key words selected were smart homes, automation, intelligent homes smart devices, sensors, interoperability. Search words that were selected were based on the area of study, which was to understand what factors impact smart home environment.

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Microsoft Excel was used for sorting, counting and analyzing the selected parameters like year, country, university,journals, author, and keywords

maximum published in 2014. The following chart gives us the count of total number of papers published year wise.

| Name of the University | Count | Name of the University | Count | Name of the University | Count |
|---|---|---|---|---|---|
| University of Florida | 1 | University of Ulster | 1 | Universidad de Zaragoza Glynd r University | 1 |
| DaeguGyeongbuk Institute of Science and Technology | 2 | University of Wales | 1 | University of Seville | 1 |
| Tamkang University | 1 | Suzhou University | 1 | University of Huelva | 1 |
| Industrial Technology Research Institute | 1 | University of South Wales | 1 | University College London | 1 |
| Universidad Politécnica de Madrid | 3 | University of Parma | 1 | Middle East Technical University | 2 |
| Wuhan National Laboratory for Optoelectronics | 1 | University of Craiova | 1 | DaeguGyeongbuk Institute of Science and Technology | 1 |
| Warsaw University of Life Sciences | 1 | TechnischeUniversität Darmstadt | 1 | Oakland University | 1 |
| University of Bern | 1 | Karlsruhe Institute of Technology (Formaly University of Karlsruhe) | 1 | University of Technology | 1 |
| Massey University | 1 | Cardiff University | 1 | Griffith University | 1 |
| Huazhong University of Science and Technology | 1 | Imperial College of Science, Technology and Medicine, Company: Nortel Networks | 1 | Brunel University | 1 |
| University of Deusto | 1 | IT University of Göteborg | 0 | School of Business, The College of Management Academic Studies | 1 |
| Universidad de Alicante | 1 | University of Washington | 1 | University of Zurich Hasselt University | 1 |
| Universidad de Castilla La Mancha | 1 | University of Pittsburgh | 1 | University of Washington | 1 |
| Polytechnic Institute of Leiria | 1 | Saarland University and company: Bosch | 1 | Carnegie Mellon University | 1 |
| University of Vigo | 1 | Imperial College of Science, Technology and Medicine | 1 | University of Craiova | 0 |
| Instituto de NovasTecnologias–Delegação de Leiria | 1 | University of Groningen | 1 | Massachusetts Institute of Technology | 1 |
| Sungkyul University | 1 | Carnegie Mellon University | 1 | RWTH Aachen University | 1 |
| Soongsil University | 1 | University of London | 1 | Pune University | 1 |
| Seoul National University of Science and Technology | 1 | Hanyang University | 1 | Fontys University of Applied Sciences | 1 |
| Dongguk University | 1 | Fontys University of Applied Sciences,Eindhoven University of Technology | 1 | University of Technology | 1 |
| Sungkyunkwan University | 1 | University of East Anglia | 1 | Mzumbe University | 1 |
| Kyung Hee University | 1 | The College of Management Academic Studies | 1 | BharatiVidyapeeth University | 1 |
| West Pomeranian University of Technology | 1 | Bangladesh University of Engineering & Technology | 1 | Massey University | 1 |
| Universidad de Zaragoza | 1 | Linköping University | 1 | UniversitiTeknikal Malaysia Melaka | 1 |
| Glynd r University | 1 | University of Stavanger | 1 | Eindhoven University of Technology | 1 |
| National Chin-Yi University of Technology | 1 | National Technical University of Athens, Energy Research Center of the Netherlands | 1 | University of Stavanger | 1 |
| University of Alabama | 1 | Universita' di Bari | 1 | Electronics Research Institute, Computers and Systems Dept, Cairo | 1 |
| Dalian Maritime University | 2 | Universiti Kebangsaan Malaysia | 1 | SAP | 1 |
| Shanghai Jiaotong University | 1 | University of Tasmania | 1 | ECN | 1 |
| University of Beira Interior | 1 | ChonBuk National University | 1 | ICET | 1 |
| University of Lisbon | 1 | National University,La | 1 | | |
| CittadellaUniversitariaCittadellaUniversitaria | 1 | Miguel Hernandez University | 1 | | |
| Beijing University of Posts and Telecommunications: Communication University of China's best | 1 | Furniture and Wood Technology Centre | 1 | | |
| Universidad de Las Palmas de Gran Canaria | 1 | University of Murcia | 1 | | |
| Universidad Politécnica de Valencia | 1 | Kobe University | 1 | | |
| IT University of Göteborg, Chalmers | 1 | Osaka University | 1 | | |
| IT University of Göteborg, Chalmers | 1 | Korea Electronics Technology Institute | 1 | | |
| Texas A&M University at Qatar | 1 | National Chin-Yi University of Technology | 1 | | |
| Nanyang Technological University | 1 | Universidad de Las Palmas de Gran Canaria | 1 | | |
| KTH-Royal Institute of Technology | 1 | Universidad Politécnica de Valencia | 1 | | |

### Bibliometric Analysis

### Year wise publishing trend of articles

From the analysis below we find that the maximum articles were published after 2012, which talks about the growing importance of research in this subject. Among these the

### Country wise articles published

Data was available for 74 Articles. These articles were affiliated to a total of 29 countries.

**Count of Papers**
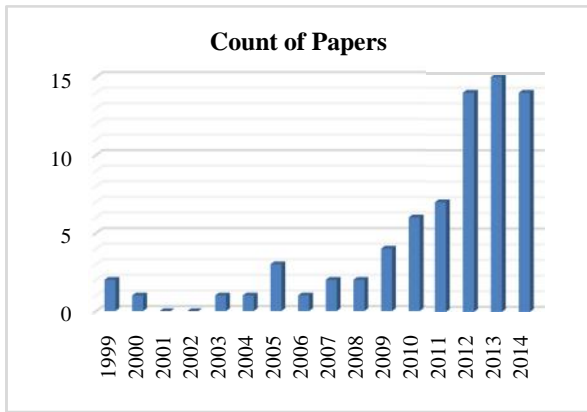
From the analysis we can see that United Kingdom has the maximum number of articles affiliated to it followed by The United States of America and Spain.Map below shows pictorial representation of above stats. It is also notable that penetration of smart home is more in the adjoining countries where more research work is done.



**Country**
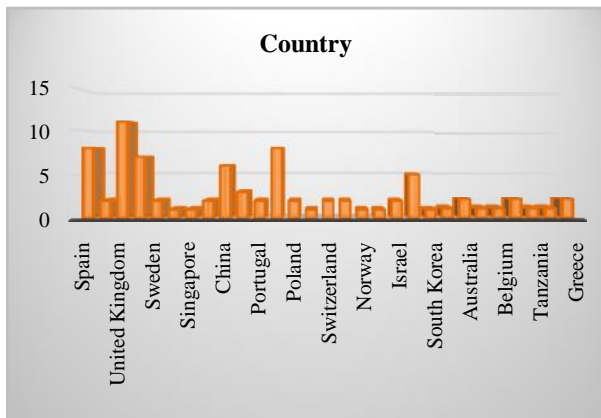
| Author Name | Count | Author Name | Count |
|---|---|---|---|
| AnkeWeidlich | 2 | Poslad, Stefan | 2 |
| ArisDimeas | 2 | Sang Hyuk Son | 2 |
| Can Basaran | 2 | Stefan Drenkard | 2 |
| Cor Warmer | 2 | Taejoon Park | 2 |
| KoenKok | 2 | Vali LIOLIOU | 2 |
| Nikos Hatziargyriou | 2 | | |

### University Affiliation

When we see the university to which the authors are affiliated, we find that the top two universities are from Universidad Politécnica de Madrid, Spain followed by Middle East Technical University, Turkey.

### Author wise no. of articles published

Total 280authors contributed towards these articles. Of which 11 authors published 2 or more papers. The shift and enthusiasm of authors to explore more is more of lately indicating its attractiveness.

### Key words used during the period

The following table gives a list of all keywords used during the period:

The top 5 keywords, which also started getting used more often during this period were

1. Smart Home
2. Home Automation
3. IOT
4. Access Point
5. ZigBee

We see two aspects emerging very prominently, one, Smart Home is very important and second the IOT along with Interoperability are playing a crucial role when it comes to a smart home environment.

### Journals

Having a dedicated journal for smart homes (Internal Journal of Smart Homes) others prominent journals publishing articles on smart homes are Sensors and Energies

The List of all other journals selected for analysis is listed below

| Keywords | 2015 | 2014 | 2013 | 2011 | 2009 | 2005 | 2002 | 2000 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| access point | 1 | | | | | | 1 | 1 | **3** |
| home automation | 2 | 3 | | | 1 | | | | **6** |
| ZigBee | 1 | | 1 | | | | | | **2** |
| activity recognition | 2 | | | | | 1 | | | **3** |
| pervasive computing | 1 | 1 | | | | | | | **2** |
| cost-effective | 1 | | | | | | | | **1** |
| mobile integration | 1 | | | | | | | | **1** |
| data mining | 1 | | | | | | | | **1** |
| users' behaviors | 1 | | | | | | | | **1** |
| smart metering | 1 | | | | | | | | **1** |
| smart home | 6 | 8 | | 4 | | 1 | 1 | 1 | **21** |
| energy usage patterns | 1 | | | | | | | | **1** |
| healthcare technology | 1 | | | | | | | | **1** |
| smart cities | 1 | | | | | | | | **1** |
| ambient assisted living | 1 | | | | | | | | **1** |
| activities of daily living | 1 | | | | | | | | **1** |
| data classification | 1 | | | | | | | | **1** |
| IOTs | 2 | | | | | 1 | | | **3** |
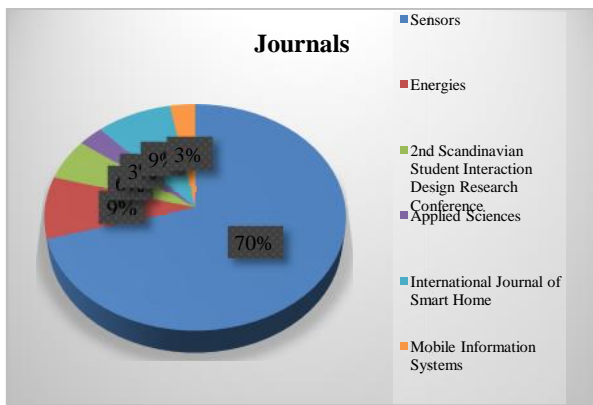
## CONCLUSION AND DIRECTION OF FUTURE WORK

Study of smart home environment is gaining importance, which can be seen from the above analysis. The study is being done widely all across the world. The countries where the research is less, is a potential area for researchers to work on. Also technology adaptation is not uniform over the world. Countries in the continents like North America and Europe have emerged and are in sync with technological innovations and hence are on a front foot in research as well as commercial aspect of smart homes. Other nations are also joining hands now and exploring many more areas and giving shape to novice technology. A more futuristic and detailed study of conclusions along with future work from the papers will guide our path towards innovation. Key words todayare not restricted to smart homes but got a dimension of IOT. Few more metrics can be added to our study like PageRank analysis, network analysis and literature review data clustering.

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