

Who are Smart Home Users and What do they Want? – Insights from an International Survey

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Abstract – Any set of devices for controlling home appliances that link to a common network and may be controlled independently or remotely are typically referred to as smart home technology. Smart homes and home automation are not completely unknown to people anymore; smart devices and sensors are part of daily life in the 21st century. Among other benefits of home automation devices, it is possible to manage home appliances and monitor resource usage, and security. It is essential to find practical information about smart home users, and possible use cases. The current survey covers smart home usage benefits and challenges for the users. The study presents the result of the collected information from different countries, and the participants are people from a variety of age groups and occupations. The questionnaire that contains both qualitative and quantitative questions was distributed through internet channels such as blog posts and social network groups. Furthermore, to generate the survey questions we conducted a literature review to gain a better understating of the subject and the related work. The research provides a better foundation for future smart home development. As a result of this survey-based study and in addition to finding the desirable home automation features, we discovered the amount of money users are ready to spend to automate their homes. Connecting the favourite smart home features to its users and the amount of money they are ready to spend on them can provide a bigger picture for the smart home industry as a whole and particularly be beneficial for developers and start-ups.

Keywords – Energy efficiency, home automation, home security, IoT, remote monitoring, smart home.

I. INTRODUCTION

According to a market research report published by Fortune Business Insights [1], the global market size for home automation was USD 64.58 billion in 2020 and based on their prediction, it is due to reach USD 163.24 billion in 2028. Wireless devices are a big portion of the market size. Because of the wireless systems and their accessibility, one can transfer any home into a smart home and start automating tasks, monitoring the activities for security reasons, or creating specific reports for resource usage for sustainability. There is no official definition for a smart home since the definition comes from different users' needs and desires. One may use the term for monitoring health complications through smart devices connected to the home, while others may consider a smart home

for automating daily tasks such as locking the doors automatically when no one is at home.

The paper uses terms such as home automation, smart devices, smart home, smart systems, and the internet of things, and these terms in the scope of this paper refer to any system or device that links to a common network and may be controlled independently and remotely. Such devices are under the umbrella of smart home technology.

Internet of Things (IoT) devices such as sensors, control devices, and monitoring systems surround us. Weiser and Brown predicted the arrival of ubiquitous computing, and with IoT, we can see this vision come to life [2]. IoT is a means for the interconnection of things based on current or advancing innovation. One of the common use cases of IoT is smart home technology-related automation. The objective of this paper is to conduct a survey-based study to gather meaningful information about home automation users and possible use cases. This study helps us to answer the following three research questions (RQ):

RQ1. Who are the smart home users?

RQ2. What are the desirable home automation features for the users?

RQ3. How much money the users are ready to spend on home automation devices?

The answers to the first question (RQ1) reveal the background of the smart home user. This would provide a foundation for answering the remaining research questions. Research question two (RQ2) is set to clarify participants' preferred home automation features, systems, and devices. Furthermore, the answer to the second research question determines the extent of the current home automation usage for the participants. As a result of the third research question (RQ3), the current survey-based study discovered how much home automation costs for the participants, how much more they are willing to invest in home automation, and what desirable features they require for a home automation system. Connecting the favourite smart home features to its users and the amount of money they are ready to spend on them can provide a bigger picture for the smart home industry as a whole and particularly be beneficial for developers and start-ups.

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The current survey-based study includes both qualitative and quantitative questions and it is distributed through internet channels. While a detailed discussion of the results will be presented in related sections, it is worth noting some key findings here. Most of the collected responses come from university-educated participants in their 30s and 40s, living in rental accommodations. Furthermore, the results indicate that although many people have heard about smart home technology, they have not yet adopted it fully. It appears that most of the participants are prone to utilizing smart light management systems which they purchased off the shelf. Security features for smart home systems are popular. However, costly systems are not attractive for the users since most of them are ready to spend a hundred euros or less on home automation systems. The survey participants are people from a variety of age groups and occupations. More details about the survey and its participants are provided in the paper related sections.

The paper is organised as follows: Section II provides an overview of the related work in the field of home automation. Section III presents the methodology employed in conducting the survey-based study. Section IV presents the detailed results obtained from the data analysis. Section V offers a critical discussion and analysis of the findings. Finally, Section VI concludes the paper, by summarising the key findings, their implications, and potential future research directions.

II. RELATED WORK

The current section is set to present the related academic work linked to this survey-based study. As mentioned earlier, the aim is to answer the research questions and find out about the desirable home automation features and the money the participants are ready to spend on home automation devices.

Shin et al. [3] published a paper about smart home user demographics. The results show that aged consumers are more likely to purchase smart home products, and systematic marketing strategies are required to gain the interest of younger consumers. According to Shin [3], the spread of smart homes has been slower than expected despite a wide variety of products developed by leading technology players like Google and Amazon.

According to Coskun et al. [4], smart home users prefer features such as remote accessibility, multi-functionality, and autonomy. Remote accessibility and autonomy are interrelated since one can have control over house appliances from anywhere and on the other hand the users would like the smart systems to work independently. Sometimes controlling the functionality is uninteresting. Users prefer to spend time browsing the Internet, spending time with the children, and watching TV instead of constantly interacting with smart systems.

There is a gap between what smart home offers and what users need. The slow adoption of home automation is covered in numerous studies. Privacy and security, trust issues, reliability, and price are some of the challenges against the mass utilization of home automation. Data Protection Regulation (GDPR) requires actions to protect citizens within the EU. This

could be a strong driver for smart home developers to implement yet stronger privacy measures. The aim is to establish a trustworthy platform that is not costly for the end users. Unless it is embraced by society and employed by customers, technology has no value [5], [6].

Reisinger et al. [7] proposed that adequate design goals are an important factor in creating a user-centred product. Reisinger realised that smart home users appreciate functionalities such as comfort, sustainability, security, lower heating and energy costs, and fun. Consumers would like to see the benefits of their investment in smart home services. Abi Sen et al. [8] suggests a way to bring down the cost of smart home by recycling old PCs and accessories. This might be a good solution since it is possible to create remote access and even voice-controlled systems at an affordable cost.

Technology is useful for supporting the elderly and people with chronic illnesses. However, that is not all, everyone can benefit from a functional system. The usage of smart meters demonstrated around three percent energy reductions and a goal-oriented smart home emphasizes the potential to help achieve energy demand cutback goals [9]. Security, safety, and monitoring are some of the features that users demand to have when it comes to purchasing smart home products. Additionally, users' income and education levels have significant effects on their choice, which means a user-centred system design is more likely to be accepted by the consumers [10], [11].

A survey conducted for the home automation domain by Zhai et al. confirmed the results of the above-mentioned studies. The several participants were from Asia and Europe. Among the smart home adaptation concerns, one can see privacy and costs-related concerns [12]. Another survey revealed that 92 % of the participants thought that smart devices had the potential to save time and energy. Furthermore, 55 % of the same survey participants believed that home automation would make life easier [13].

Smart systems are not widely adopted by mainstream users [3], [4]. This can be related to the high costs, privacy concerns, or the absence of a user-centred design. Yet, users still have a positive view of the subject. The literature also offers possibilities to address user interests. Our study aims to further improve the understanding of smart home user concerns and their favourite features. Additionally, the result of this questionnaire provides details about the monetary value of home automation for the participants. The next section discusses the methodology used to complete this paper.

III. METHODOLOGY

The current study employs a survey-based research approach to gather insights into smart home users and their preferences. This inductive research methodology involves collecting data from participants and subsequently analysing the collected data to identify trends, patterns, and generalizations that can contribute to the development of future smart home technologies.

To ensure a comprehensive data collection process, the survey questionnaire was designed to include both qualitative and quantitative questions that align with the research questions. The complete set of survey questions is available in Appendix 1. The questionnaire is organised in five sections, and participants are directed to the appropriate section based on their responses in the previous section. Figure 1 illustrates this process and indicates the percentage of participants directed to different paths within the survey.

The initial section of the survey focuses on gathering metadata from participants, including information about their background, gender, age group, and other relevant demographics. This metadata provides valuable contextual information that aids in understanding the characteristics of the survey participants.

To ensure the reliability and credibility of the study results, it is important to address the question of sample size and its adequacy. In this research, data were collected through internet channels such as social media and forums from a total of seventy-three survey participants spanning nine countries and five distinct age groups.

By implementing a sampling strategy, the study aimed to ensure a diverse representation across different geographical locations and age groups. This intentional selection process aimed to capture a broad range of perspectives and experiences related to home automation. By including participants from various countries and age groups, the study was able to gather valuable insights that reflected the global nature of the smart home industry.

By conducting a survey-based study and gathering data from a diverse group of participants, the research aims at providing valuable insights that can inform future smart home development. The results obtained from the survey will be analysed and discussed in detail in Section IV, shedding light on the preferences, needs, and expectations of smart home users.

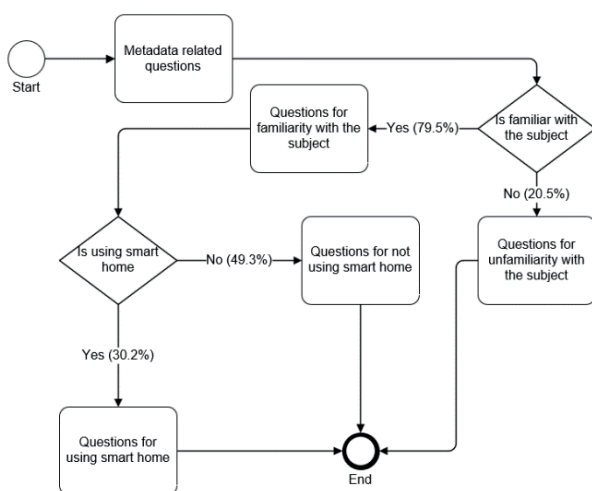


Fig. 1. Survey process and structure.

IV. RESULTS

The current section of the research report is focused on addressing the research questions that were proposed at the beginning of the study. The section IV is divided into three sub-sections, each is dedicated to analysing and presenting the results of the survey that was conducted as part of the research.

Each of these sub-sections contains a variety of charts and tables that are designed to help visualize and interpret the data collected from the survey. These charts and tables are an important tool for presenting the findings of the research clearly and concisely, and they allow the reader to easily understand the key trends and patterns that emerged from the data.

In addition to presenting the survey results, the current section also includes detailed explanations and interpretations of the data, highlighting any notable trends or patterns that were identified. This is an important aspect of the research process, as it allows the researchers to draw conclusions and make recommendations based on the data collected. Overall, the current section is a crucial part of the research report, as it presents the findings of the study clearly and comprehensively which helps to provide insights and recommendations for future research or practice.

A. Who are the Smart Home Users? (RQ1)

Seventy-three people responded to the survey questions from nine different countries (Finland, Sweden, The Netherlands, Australia, India, Malaysia, the United States of America, Germany, and Russia) and most of them were in their 30s and 40s. In today's global market technology crossed boundaries and smart home systems are found in many places. The current study did not put any restrictions on the origin country of the participant. This section presents the survey results collected from the following countries. Additionally, Table I is set to present detailed information on the survey participants which is part of the answer to the first research question (RQ1).

TABLE I
DETAILS ABOUT THE SURVEY PARTICIPANTS

Gender	Age Group	Percentage of Participants
Female	Less than 20	0 %
	20–30	16.4 %
	31–40	26.0 %
	41–50	8.2 %
	Above 50	4.1 %
Male	Less than 20	0 %
	20–30	13.7 %
	31–40	23.3 %
	41–50	5.5 %
	Above 50	1.4 %
Prefer not to say	Less than 20	0 %
	20–30	1.4 %
	31–40	0 %
	41–50	0 %
	Above 50	0 %

Most of the participants are twenty to fourth years old. The presented results in Table I show that 54.8 % of the participants are female, 43.8 % are male, and 1.4 % preferred not to enclose their gender. The participants were also asked about their education level. 93.2 % of the participants have a university education:

- School – 1.4 %
- High school – 2.7 %
- Vocational school – 2.7 %
- University – 93.2 %

After processing the results, 34 unique professions were recognized. The professions /occupations then were divided into three categories: Information technology (IT), non-IT professions, and students. Table II presents results associated with professions.

TABLE II
PARTICIPANTS' PROFESSIONS (UNIQUE ENTRIES)

Profession Category	Number of Unique Entries	Example of Entries
IT professions	7	Software Developer, IT Professional, IT Consultant, etc.
Non-IT professions	25	Head of Sales, HR Professional, Banking, Kindergarten Teacher, etc.
Students	2	Doctoral student, etc.
Total of Unique Entries:	34	

In addition to the gender, age, education, and profession the survey inquired about participants' living arrangements. Figure 2 contains three charts that provide more details linked to this inquiry. Most of the entries belong to people who own their homes (41–100 m²), which are placed in a town.

Smart Home Familiarity

The next section of the questionnaire was dedicated to finding out the level of familiarity of the participants linked to the research topic. 30.2 % of the people responded that they were extremely familiar or very familiar with the home automation topic. However, 20.5 % were completely unfamiliar with the topic. The participants were then instructed to explain their understanding of the topic (How do you define Home Automation?).

As seen in Fig. 3, some of the people (20.5 %) are unfamiliar with the research subject. The results do not show any particular age group participants from different age groups that have chosen the unfamiliarity option. It is important to know if they would like to know about home automation, which means they can be potential users in the future. Figure 4 shows the responses to the question (Would you like to learn more about Home Automation?) The question was specifically designed for the participants who are unfamiliar with the subject, which is 20.5 % of the total entries.

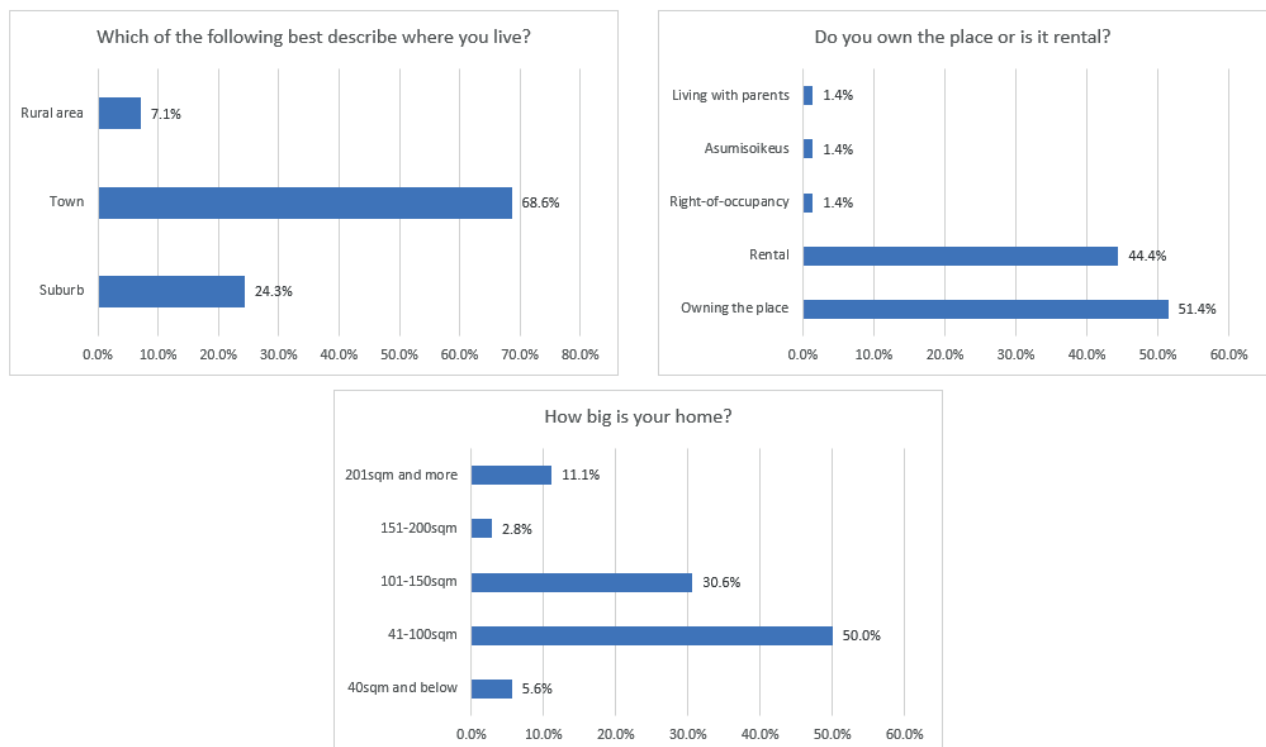


Fig. 2. Living arrangements of the participants.

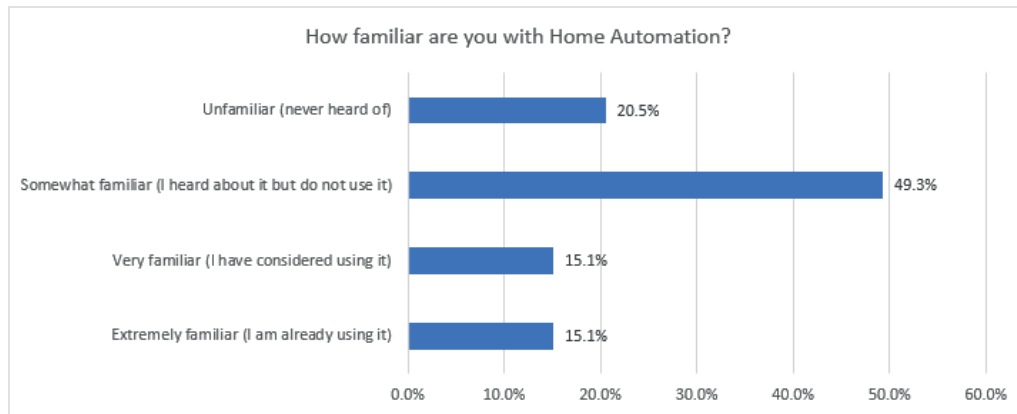


Fig. 3. How familiar are you with Home Automation?

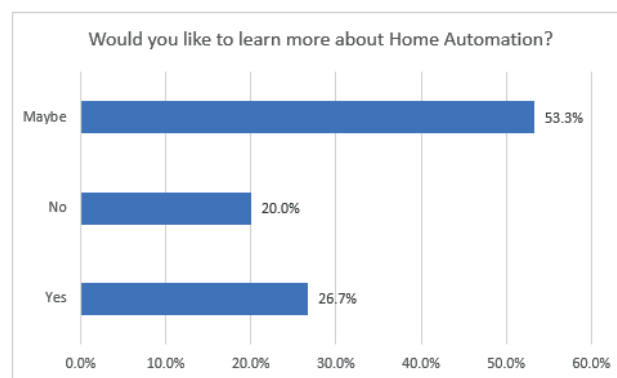


Fig. 4. Would you like to learn more about Home Automation?

B. What are the Desirable Home Automation Features? (RQ2)

The survey contains several open-ended questions related to participants' understanding of home automation and its desirable features. The current section is set to answer the second research question (RQ2) by summarising the results of the conducted survey. Concerning the definition of home automation for the survey participants the following categories were identified:

- Home automation is the ability to *remotely control and monitor* home appliances;
- *Resource management* is possible with smart home systems;
- Home automation is *task management* through technology;
- It means the ability to *automate daily tasks* without human intervention;
- Adding features to the home to ensure *security*.

The list above stresses five different categories and all the survey entries linked to the smart home definition can be linked to one of these categories: remote accessibility, resource management, task management, task automation, and security. It is interesting to point out that some people define a smart home as a means for task management without human intervention. Furthermore, according to the survey results,

security and remote accessibility are inseparable parts of a smart home system. As explained earlier and shown in Fig. 1, the survey had different paths for people who were using smart home systems and the ones who were not using them. Figure 5 contains four questions; it shows the results of the questions related to smart home features and functionalities.

- Results that are marked with green and grey belong to people who are familiar with home automation but currently are not using it.
- Results that are marked with the orange and blue belong to people who are currently using home automation.

Participants could choose multiple items from the given list. Some interesting outcome is discovered when analysing Fig. 5. For example, 73.7 % of people who are familiar with smart home technology would like to have security as a functionality (marked with grey). Yet 74.3 % of people who are current users of home automation have security functions available. The importance of security for home automation is revealed here. According to Fig. 5, light management is a popular feature offered by the current home automation products. The green colour shows that 80 % of people who are familiar with home automation know the light management functionality and 85.7 % (marked with orange) of people have the light management functionality as part of their home automation system.

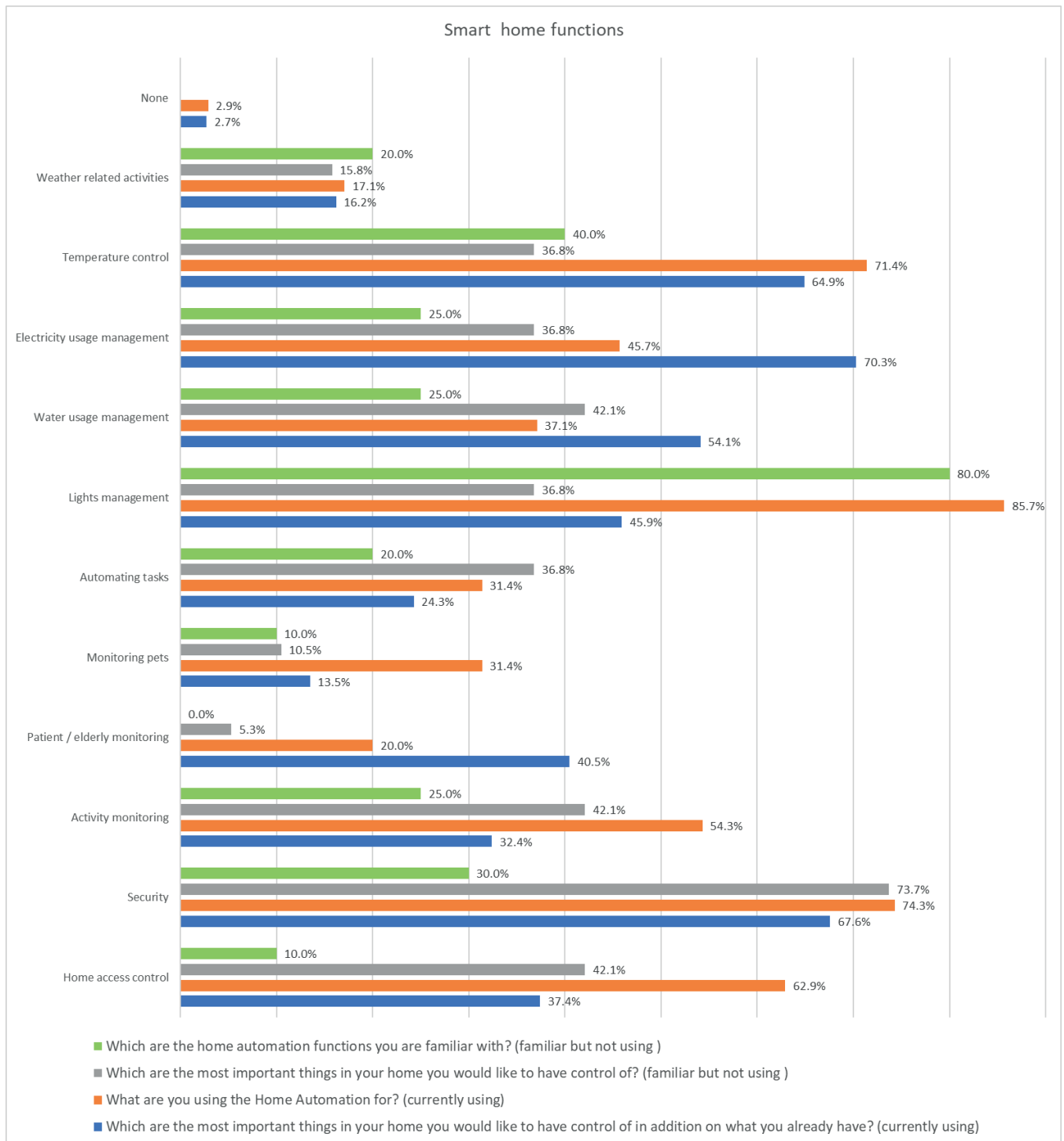


Fig. 5. Smart home functions.

Benefits and Drawbacks of Smart Home

The survey had dedicated sections for entries linked to the benefits and drawbacks of home automation systems. The answers are separated based on people who are using home automation currently and the ones who are familiar with the technology but not using it. The following two tables are summaries of the collected survey results.

TABLE III

ENTRIES OF PEOPLE WHO ARE FAMILIAR WITH HOME AUTOMATION BUT NOT USING IT

Question	Summary of responses
What are the benefits you expect from Home Automation?	Remote accessibility and monitoring; resource management; saving money; saving time; should be easy to use
What are the drawbacks you see in Home Automation?	Technology can be misused; security and privacy concerns; potential system failure; does not fulfil expectations; it is expensive; installation complexity

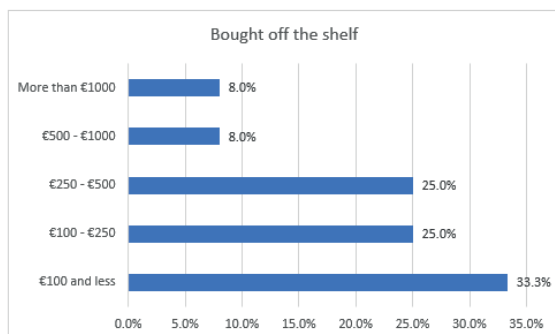
TABLE IV

ENTRIES OF PEOPLE WHO ARE CURRENTLY USING HOME AUTOMATION

Question	Summary of responses
What benefits have you experienced using Home Automation?	Saving energy; voice control; remote accessibility and monitoring; easy to use; security
What are the biggest drawbacks based on your experience while using Home Automation?	Hard to configure; expensive; it can make us lazy; kids can disable remote monitoring; security and privacy concerns; Integration and compatibility; system failure and reliability

C. The Monetary Value of Home Automation (RQ3)

Survey participants are divided into two groups to gain a better picture of the monetary value of home automation. The ones who are using home automation (63.8 %) and the ones who are not using the technology but are familiar with the subject (36.2 %). The current subsection has two subparts, the first part is dedicated to smart home users and the second part discusses the entries for the users who are not using smart homes but know the subject.



Users of Home Automation

The users of home automation have acquired the technology by purchasing it off the shelf or developing it on their own. The current survey study discovered a difference in money spent on these systems by the two groups. Figure 6 presents that 61.9 % have bought the systems off the shelf.

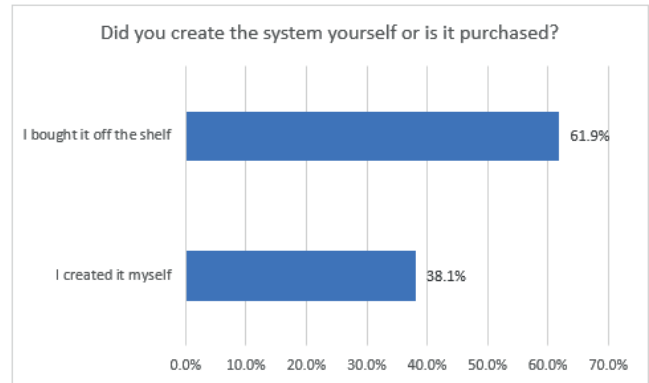


Fig. 6. Purchased it off the shelf or developed.

People who bought their products off the shelf have spent more; the results show that most of them paid approximately 100–500 euros to use the technology. Yet, most of the ones who created the system themselves have approximately spent 100–250 euros. Additionally, the survey asked both groups about the extra money they are ready to spend on home automation for enhancing it. Figures 7 and 8 are dedicated to presenting the results.

D. Non-users but Familiar with the Technology

Non-users were directed to answer questions linked to the monetary value of home automation. Figure 9 is set to present the results for the presented questions.

The current survey-based study, conducted among social media and internet users from nine different countries, has provided valuable insights into the preferences and needs of smart home users. In this section, we critically discuss the findings and implications of the study, focusing on key areas of interest for developers and start-ups in the smart home industry.

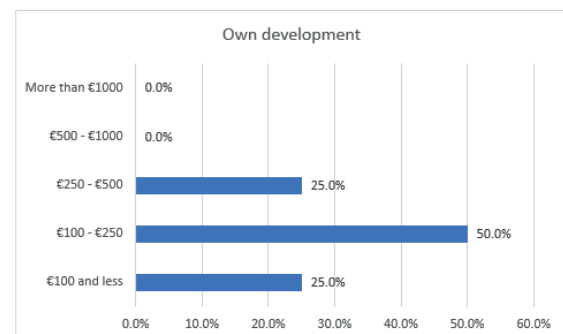


Fig. 7. Monetary value of home automation in use.

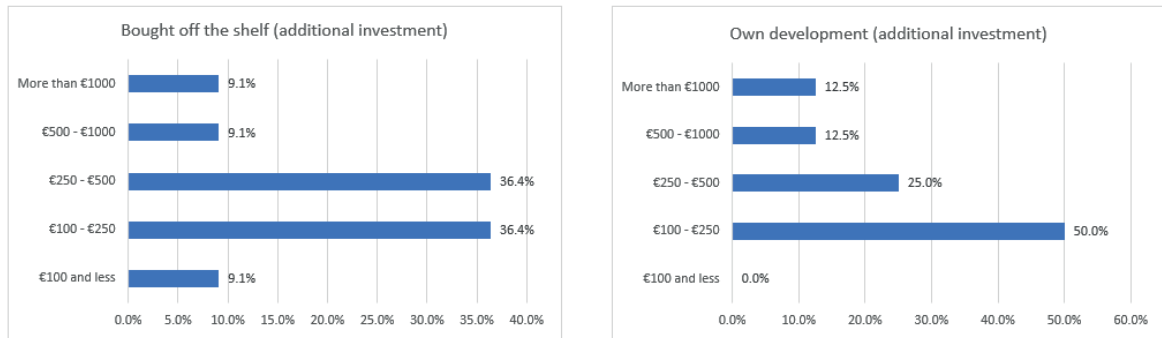


Fig. 8. Additional investment in home automation.

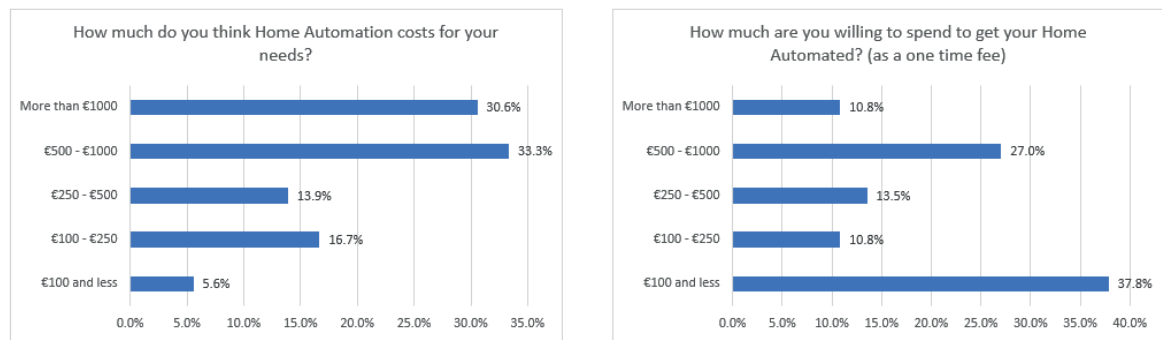


Fig. 9. Monetary value of home automation for non-users.

V. CRITICAL DISCUSSION

A. User Profile and Adoption

The study findings indicate that the majority of participants are university-educated individuals in their 30s and 40s living in rental accommodations. It is noteworthy that many respondents have heard about smart home technology but have not yet embraced it (Fig. 3). This represents a significant opportunity for developers to explore the barriers to adoption and design strategies to increase user acceptance. Future research efforts should delve deeper into understanding the specific reasons behind this hesitation and explore innovative ways to address them.

Recommendation

Developers should invest in targeted marketing campaigns and educational initiatives to raise awareness and alleviate concerns regarding smart home technology. Emphasising the practical benefits, such as increased security and convenience, can help overcome user scepticism.

B. User Needs and Desired Features

Regarding the desired features of smart home systems, the study findings reveal that simple automation features like light control are commonly used, while security features are highly desired (RQ2). However, participants expressed a desire for broader functionalities, including energy and water management as well as task automation (Figs. 5 and 6). These

findings highlight the need for developers to prioritize and expand the range of features in their smart home products.

Recommendation

Developers should focus on enhancing the security aspects of smart home systems, as this remains a top priority for users. Additionally, integrating energy and water management functionalities, along with task automation capabilities, can enhance the overall user experience and appeal of smart home products.

C. Drawbacks and Concerns

While smart home products offer numerous benefits, this study also identified several drawbacks. Reliability and high costs were among the key concerns raised by participants. Additionally, users expressed worries about privacy and security issues associated with current smart home systems. These concerns should be addressed to foster user confidence and wider adoption, ensuring that smart home technology becomes more accessible and affordable for a broader range of consumers.

Recommendation

Developers should prioritize the development of reliable smart home systems by rigorously testing and improving product performance. Furthermore, addressing privacy and security concerns through robust data encryption, secure network protocols, and transparent data handling practices can instil trust among users.

D. Compatibility and Integration

The study findings suggest that the cost of smart home systems is often attributed to the lack of compatibility between products from different manufacturers and the complexity of installation (RQ3). Integrating smart home systems with existing household products and appliances can significantly reduce the need for costly upgrades.

Recommendation
Developers should strive for interoperability and standardization in the smart home industry. Collaborative efforts and partnerships among manufacturers can lead to more seamless integration of smart home systems with existing products, thereby reducing costs, and enhancing user experience.

E. Validity of the Results

This sub-section examines the validity of the results obtained in the survey-based research, focusing on four key aspects: construct validity, internal validity, external validity, and reliability.

Construct validity pertains to the accurate interpretation and measurement of theoretical constructs. The study ensured alignment with established definitions in the field when assessing constructs related to smart home development. Validated survey instruments and clearly defined variables were employed to enhance construct validity.

Internal validity concerns the study design and the extent to which the results can be attributed to the collected data. Rigorous data collection procedures, well-designed survey questions, and appropriate statistical analyses were employed to minimize the influence of confounding variables and enhance internal validity.

External validity addresses the generalizability of the research findings. The study sample consisted of 73 participants from 9 countries and 5 age groups, deliberately designed to ensure diversity. While caution is advised in generalizing the findings to the entire population, the study's approach enabled a comprehensive exploration of different perspectives and contributed to the understanding of smart home users.

Reliability focuses on the consistency and reproducibility of the study results. Standardized survey instruments with established reliability measures were employed, following best practices in survey design and implementation to enhance reliability. Transparency was maintained by making the survey instrument and data analysis code available for future replication.

In summary, although the sample size may appear modest, the deliberate sampling strategy aimed to capture diverse perspectives on smart home development. Limitations inherent in survey-based research, such as potential response bias and challenges in achieving a fully representative sample, were acknowledged. Nevertheless, careful data analysis and interpretation allowed for the identification of valuable patterns and trends. The study findings provide a foundation for further research and future efforts can consider expanding the sample size to strengthen the study conclusions.

VI. CONCLUSION

The fast advancement of technology can be overwhelming and keeping up with user requirements can be challenging for developers. The current survey-based study has been set to answer key questions linked to home automation development. What are the desirable features for the users and what is the monetary value they assigned to the requirements? The related work indicates clear demands from home automation users. Security, privacy, and price are among the most required concerns [5], [6]. Our research shows that DIY (do it yourself) systems have lower price tags than purchased ones. Furthermore, people who are not using smart home technology expect a higher price for the systems than their actual cost (the results are provided in Figs. 9–11).

In the end, the question is, what is the future of smart homes, does it even have a future, and is there enough interest? According to Fig. 1, most people are familiar with smart home technology, which means there is an interest in home automation. Yet, facts like privacy and security concerns and the potentially high price of such systems might reduce their usage. The authors' recommendation for start-ups is to conduct targeted and dedicated research about the potential customers and use cases. The current survey participants are from different age groups, genders, and nationalities. This can provide a better picture of the global market and its demands, which could be particularly beneficial for developers and start-ups.

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A. APPENDICES**A.1. SURVEY QUESTIONS****Home Automation Usage**

What is your gender?

How old are you?

What is your profession?

What is the level of your education?

What is the field of your education (if applicable)?

Country, where do you live?

Which of the following best describes where you live?

Do you own the place or is it a rental?

How big is your home?

How familiar are you with Home Automation?

What does Home Automation mean to you?

Unfamiliar with the subject

Would you like to learn more about Home Automation?

Familiar with the subject

Are you using any Smart technology or Home Automation technology now?

Not using Home Automation

Why are you not using the Home Automation technology?

Which are the subjects for home automation you are familiar with?

Which are the most important things in your home you would like to have control of?

What are the benefits you expect from home automation? (You may list several items)

What are the drawbacks you see in Home Automation? (You may list several items)

How much do you think Home Automation costs for your needs?

How much are you willing to spend to get your Home Automated? (As a one-time fee)

Thanks for participating in this survey. Please provide your e-mail address if you agree to have an interview about the subject.

Using Home Automation

What are you using the Home Automation for?

What benefits have you experienced using Home Automation?

What are the biggest drawbacks based on your experience while using Home Automation?

Did you create the system yourself or is it purchased?

How much have you paid for your existing Home Automation?

Which are the most important things in your home you would like to have control of in addition to what you already have?

How much more are you willing to invest in your Home Automation?

Thanks for participating in this survey. Please provide your e-mail address if you agree to have an interview about the subject.