SmartSync: Revolutionizing Remote Work with AIoT-Virtual Office Interactivity

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Abstract. Our homes are where we spend a significant portion of our time, engaging in activities from sleeping to dining. However, due to the COVID pandemic and various economic factors, an increasing number of people have started working from home, thereby escalating the demand for professional and smart home offices. A pivotal aspect of enabling effective work from home is the integration of smart technology in these offices. This objective can intriguingly be achieved by applying the concept of the Artificial Intelligence of Things (AIoT). In this work, we propose a system for real-time interaction between the user and the office environment, leveraging AIoT to collect and analyze data from both physical surroundings and virtual meetings. This approach empowers users, especially those participating in virtual meetings on platforms like Zoom, to have enhanced control over both their virtual and physical workspaces. Our initial research underscores the considerable utility and necessity of AIoT-enhanced meetings, presenting users with flexible and intelligent options to manage their work and surroundings more effectively.

Keywords: Artificial Intelligence of Things, Real-time, Virtual meetings, Physical workspaces

1 Introduction

The rise of remote work, accelerated by the COVID-19 pandemic, has necessitated innovations in technology to maintain productivity and collaboration. Among these innovations, the integration of Artificial Intelligence (AI) and the Internet of Things (IoT), collectively referred to as AIoT, has emerged as a critical enabler of virtual office interactivity. This section explores the current state of research on the use of AIoT in enhancing remote work environments, focusing on virtual office interactivity.

AIoT combines the analytical capabilities of AI with the connectivity and data collection capabilities of IoT. This synergy is particularly beneficial in remote work settings where maintaining connectivity and productivity across distributed teams is essential. According to research [3], AIoT facilitates smart environments by enabling devices to interact intelligently, thereby enhancing user experiences and operational efficiency.

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Virtual Office Interactivity Virtual office interactivity refers to the ability of remote workers to engage and collaborate as effectively as they would in a physical office. AIoT technologies play a significant role in this context by providing tools that simulate physical office interactions. For instance, smart conferencing systems equipped with AI capabilities can improve video and audio quality, automatically adjust settings based on user preferences, and even provide real-time interactivey between the teacher and students [10]. AIoT can create intelligent workspaces that adapt to the needs of remote workers. This includes automatic adjustments to lighting, temperature, and noise levels based on the presence and preferences of users. Research by [7] demonstrates that such environments can significantly improve worker comfort and productivity.

Web-conferencing systems (WCS) like Zoom and Microsoft Teams have been around for some time. First adopted in the business world to facilitate professional interactions between companies and distributed work[11], WCS uses include distance education (e.g. Mupinga [8]), telehealth (e.g. Brecher [1]), and more recently personal use, such as by long-distance families (e.g. Follmer et al. [4]; King-O'Riain [5]). The use of WCS doubled between 27 March and May 31 2020, rising to 24 percent of U.S. households (Consumer Technology Association [9]). Not surprisingly, the trend towards working from home whenever possible contributed to this increase, but people also started to use WCS to support the everyday activities related to school, communities, friends, and families.

Despite radical improvements in the infrastructure that underlies web conference systems, such as faster internet connections and the widespread use of mobile devices, significant challenges persist. One of the main issues is the comfort of the home environment, which can be affected by factors such as noise, temperature, and lighting. These environmental factors can significantly impact the effectiveness and comfort of remote work and virtual meetings.

The integration of IoT in virtual meetings enables the automation and control of various peripheral devices, creating a more immersive and interactive experience for participants. This goes beyond the conventional audio-visual aspects to encompass environmental controls, such as lighting and temperature, and even extends to more complex systems like automated note-taking, attendance tracking, and real-time feedback mechanisms. Such advancements not only enhance the convenience and comfort of participants but also significantly elevate the effectiveness of communication and collaboration in remote settings.

This paper explores the various ways in which IoT can revolutionize virtual meetings. We delve into the technological advancements that make this integration possible, demonstrate successful implementations, and discuss the potential challenges and solutions in IoT with virtual meeting technology. The goal is to provide a comprehensive overview of how IoT can be leveraged to create more engaging, productive, and intuitive virtual meeting experiences, marking a significant step forward in remote collaboration technology. Our contribution can be presented as follows:

- We demonstrate the capability to connect virtual meeting platforms such as Zoom with office electrical peripherals, such as lighting and air conditioning. These devices can automatically turn on and off with the initiation and termination of meetings.

- We have developed a basic language agent that interacts with users, providing updates on specific conditions during the meeting, such as notifying when all registered users have entered the meeting.
- We have developed a system that monitors the attendance of meeting participants. If a specific participant is late by a certain amount of time, the system automatically sends reminder emails.

In summary, We develop an AIoT-based system for real-time environmental data analysis in home offices. Our implementation is a user-friendly interface for controlling both virtual and physical aspects of remote meetings.

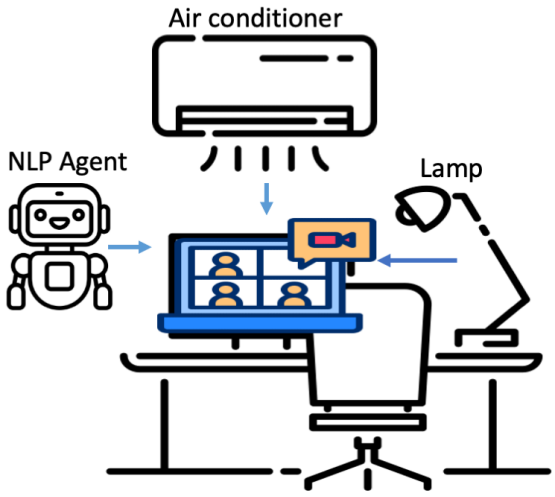

Figure 1: Illustrates our concept featuring furniture elements such as lamps and air conditioning units interconnected with a virtual meeting application to automate their functionalities. Moreover, A language agent is incorporated to notify users about specific events.

2 Background

Integrating IoT with home meeting peripheral devices to facilitate user functions and create a notification system for certain conditions can enhance the user experience. Importantly, this section covers the evolution of web conferencing systems, its current gaps, and the justification behind our suggested advancements. This section covers the following points :

- An overview of the web conferencing system and its evolution, key features, and it impact on global communication.
- Areas for improvement and gaps in the current meeting platforms for home offices.
- Justification for the suggested improvements in home office meetings.

Web Conferencing Systems The reliance on video conferencing has increased since the COVID-19 pandemic. This has led to a higher demand for e-conferencing, facilitating global and technological advancements in conducting business and education in such environments. The virtualization of meetings enhances interaction among teachers, colleagues, clients, and associates, thereby fostering collaboration towards achieving the organization's objectives. Web conferencing platforms enable participants to conduct virtual meetings and communicate over the Internet. These platforms provide not only audio and video communication, but also additional features such as screen sharing, recording, and document sharing during the meeting. Furthermore, web conferencing has proved necessary in many applications such as remote education and employees meetings allowing for seamless communication. Zoom, Google Meet and Teams are the most known and used platforms, they are very useful web-conferencing platforms. Zoom is a cloud-based online platform used for web conferencing, webinars , chats, and meeting recordings. Zoom has grown in popularity widely with millions of online users daily. Table 1 shows the estimated Zoom daily meeting participants over the last years. Participants can join meetings using cameras, phones, or webcams. Zoom offers both free and Pro versions; the Pro version provides additional functionalities and capabilities, while the free version is suitable for users using the platform's basic functions. Zoom platform provides the user with APIs that can be very helpful in providing the developer with functionalities such create meetings, get the meeting participants, meeting status and more. Unfortunately, the potential of these APIs is not fully leveraged in enhancing the user experience for home and office meetings. In other words, most development focuses on software plugins. However, integrating hardware components, such as controlling smart office applications during meetings, has not been widely explored. Such work could lead to novel patents that enhance users' daily meetings. Because of Zoom's widespread use as the main communication channel during the COVID-19 pandemic, and its likely continued prevalence in education and the workplace, it is important to analyze what aspects of video conferencing are working for users, and what are not, especially for those working remotely. In other words, understanding users' needs for smooth meetings in a smart-controlled environment is very important.

Date	Meeting participants
2019	10 Million
March 2020	200 Million
April 2020	300 Million
December 2020	350 Million

Table 1: Zoom daily meeting participants statistics[2]

Areas for improvement and gaps: Unfortunately, many home offices are not ideally equipped for work purposes. They should be supported with proper lighting, air conditioning, notification systems, and safety tools for practical use. The home office should be as comfortable and practical as official offices and adapted for user comfort

and productivity. In this work, we demonstrate a prototype showing how such a room should look like. We recommend integrating AC devices such as, but not limited to, AC lighting sources, air conditioning, and LED strip lights. These devices can enhance the human interaction experience by automatically being turned on/off and adjusted at the start and end of meetings, thereby making the meeting space more comfortable and efficient.

During meetings, various situations can occur, such as participants joining the meeting, late arrivals, and delays while waiting for all participants to join. Monitoring these conditions can be challenging, which necessitates the implementation of a supportive notification system with physical alerts, like LED display or sound notifications.

Justification for the suggested improvements i As shown it the previous statistics there is a significant portion of the workforce relying on home offices. This large demographic necessitates a focus on optimizing home work environments. By integrating advanced AC devices, such as smart lighting and air conditioning systems, the user experience can be greatly enhanced. These devices can automatically adjust to create an optimal work environment, thereby reducing manual effort and distraction for the user. Additionally, The dynamic nature of meetings, with participants joining at different times or experiencing delays, poses a challenge in maintaining awareness and coordination. A supportive notification system with physical alerts, such as LED displays or sound notifications, is essential to monitor these conditions effectively. This ensures that all participants are on the same page and reduces potential disruptions.

3 Methodology

Improving the user experience in virtual meetings involves focusing on two key aspects of web conferencing systems. The first aspect revolves around the use of software plugins. These are software-based solutions that can be seamlessly integrated into a virtual meeting application. The second aspect pertains to hardware implementation, which involves configuring home devices to activate under specific conditions. In the following sub-sections, we will delve into each of these methods, detailing how they can be effectively implemented to achieve the desired results.

3.1 Implementation

Hardware Implementation To demonstrate the feasibility of controlling external equipment during a virtual meeting, several key components are required. These include:

A micro-controller is a small electronic circuit equipment that used for handling other parts of an electronic system. It typically consists of a microprocessor, memory, and connected peripherals. For our purpose, we utilize the Arduino Uno [**?**], a microcontroller board based on the ATmega328P. It features 14 digital input/output (I/O) pins, with 6 capable of Pulse Width Modulation (PWM) outputs, 6 analog inputs, a USB connection for data and power, and a reset button. The Arduino can be powered either through a 9V supply using the power jack or via its USB connection.

Peripheral Connection To replicate a real home office meeting environment for testing purposes, we utilize commonly used devices such as a desktop lamp, a fan, and

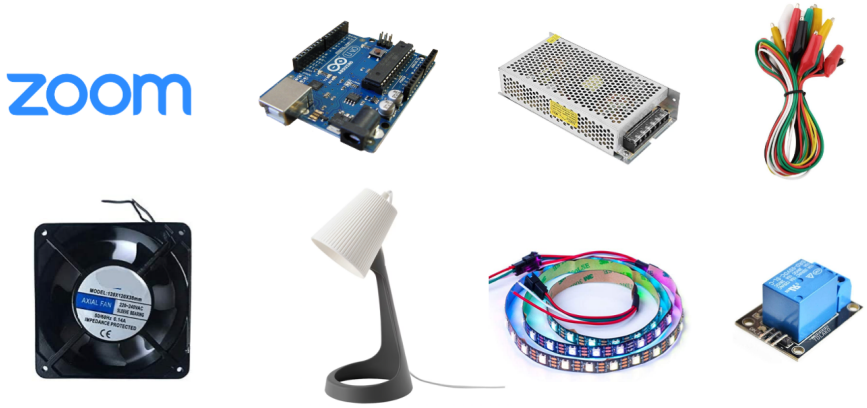

Figure 2: Represents the main components used in proof of concept for the hardware implementation.

decorative LEDs (WS2812B) to convey specific condition/information. The desktop lamp and fan are powered by a 220 Volt AC supply. The decorative LEDs (WS2812B) require a 5 VDC power source with a current draw of 18 AMPs. The WS2812B consists of 60 RGB LEDs and it is waterproof.

A Relay is an electromechanical switch. Unlike manual switches, a relay is an automatic device that connects or disconnects two circuits. When a voltage is applied across its power terminals, the relay activates or deactivates the circuit in response to an electrical signal sent to its excitation pin. Relays are widely used in various applications, including automotive systems, lighting control systems, traffic management, and computer interfaces.

Virtual meeting platform and APIs For our project, we chose the Zoom platform due to its widespread popularity, although alternatives like Google Meet and Webex are also viable options. To execute commands within a programming environment, we utilized APIs. Zoom offers an extensive array of functions, including creating and ending meetings, setting up breakout sessions, and accessing live participant lists and etc. However, it's important to note that executing these commands necessitates the generation of a token for user identity verification.

Integrated Development Environment (IDE) An IDE is a software suite that facilitates the creation of applications in various programming languages, integrating essential developer tools within a single graphical user interface (GUI). For our project, we utilized PyCharm, a Python-specific IDE. PyCharm is designed to offer a range of important tools for Python development, enhancing the coding experience and supporting data science development in a user-friendly environment. Additionally, PyCharm offers robust debugging tools, making it an effective choice for both beginners and expert users.

Communication Protocol To establish communication between the microcontroller and peripheral devices, a suitable communication protocol is required. In the realm of

Python development, there are several such protocols, including PySerial and Pyfirmata. PySerial is a well-defined library that provides support for serial connections across a diverse range of devices. For our project, we opted for the PySerial library over Pyfirmata [6]. It's important to note that using multiple communication protocols simultaneously can lead to numerous errors and communication issues. Therefore, it is advisable to use a single communication protocol consistently across all connected peripheral devices.

Software Implementation The objective of the software implementation is to develop a basic agent that assists users with physical tasks. This includes functionalities like sending a reminder email if specific participants are late, notifying the host when all participants have joined, and using WS2812B LED indications to signal the host that the meeting can begin once all attendees have joined. Additional essential elements involve an email account with SMTP enabled for automatic API-driven email sending, an audio recording feature to play sounds when specific actions are triggered, and a Zoom business account for accessing live meeting participants' metadata. For a more advanced setup, text-to-speech technology can be employed to customize audio notifications based on triggered actions.

3.2 System Design

Hardware Design The hardware design aims to allow the user controlling his household equipment such as desktop lamp, fan and RGB led to indicate certain information. First we do the wiring, to automate the on/off functionality of AC devices, we cut one wire in the device's circuit and connect a relay to both cut ends. Secondly, the relay's excitation pin is connected to a digital pin on the microcontroller. This setup enables the joining and disjoining of the circuit. Additionally, the relay's VCC (Voltage Common Collector) supply is connected to the power supply, enabling the relay's operation. Next, each connected AC device will have output wire from the excitation pin, these pins will be connected to digital pins of the microcontroller to allow applying input voltage to the excitation pin to turn off/on the device. To power the microcontroller, it can be fed from an external power source using a power jack or via a USB connection. However, using an external power source is preferable, as it allows the microcontroller to safely provide the necessary current for sensors and connections. Furthermore, for DC devices such as the WS2812B, a minimum of 18 AMPs at 5 VDC is required. Therefore, a 20 AMP power supply was utilized to provide the necessary current to the WS2812B. Additionally, the signal pin of the WS2812B is connected to a digital input pin on the microcontroller.

Coding for Hardware Design This section presents the implementation details of the code used for hardware design.

Algorithm 1 Algorithm For Hardware Design

Require: The host starts a meeting.
Ensure: All the AC and DC devices are connected to their feeding power supply and they operate in their default values.
Set the default values of hardware components.
→ Turn off the desktop lamp.
→ Turn off the fan
→ Turn WS2812B to green color

while True **do**
if Meeting Started **then**
→ Turn On the desktop lamp.
→ Turn on the fan
→ Turn WS2812B to red
end if
if All participants join **then**
→ Turn WS2812B to Blue
→ Play Audio recording to inform the host
end if
if Meeting closed **then**
→ Set the connected devices to default values.
break
end if
end while

Mobile Application Design The practical implementation of this concept in a real-world environment requires the development of mobile and desktop applications that capture users' preferred configurations. It is crucial to allow users to customize their applications by choosing whether certain devices should be on or off, offering a wide range of options to align with individual preferences. Consequently, a Graphical User Interface (GUI) for the mobile application has been developed. This GUI enables users to input their configurations and manage the connected devices accordingly. Notably, Zoom provides an option to run meetings through a customized, standalone application, not just as a plugin development.

Software Design of AI Agent In developing the software for the AI agent, we leverage several components from the software implementation. Additionally, a mail account with SMTP (Simple Mail Transfer Protocol) enabled is required, alongside pre-recorded audio files to be played when specific actions are triggered. The algorithmic structure of the AI agent is outlined in Algorithm. 2.

The AI agent's operation begins with the start of a meeting. It automatically sends an email invitation to the meeting participants, including a URL for joining the meeting. Notably, the agent is programmed to send reminder emails to participants who haven't joined after a certain time threshold, which is set by the meeting host. Furthermore, once all participants have joined, the agent notifies the host, indicating that the meeting

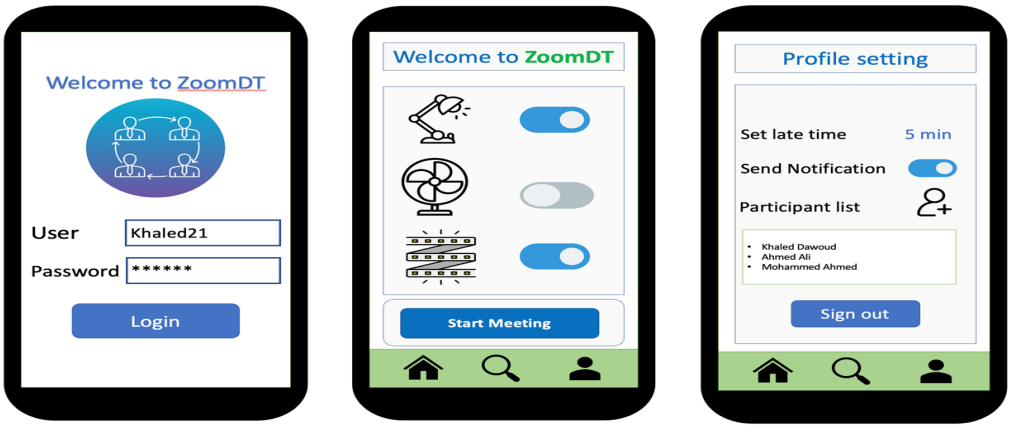

Fig2. Represents the layout of the mobile application, it gives the user the options to choose which devices to be triggered in response to certain actions.

can commence with all attendees present. This functionality enhances the efficiency and management of virtual meetings.

Algorithm 2 Algorithm For SmartSync Agent Design

Require: Mail account and Zoom Account.
Ensure: SMTP is enabled.

while True **do**
  if Meeting Started **then**
    → Send Welcoming Email.
  end if
  if Specific participant is late **then**
    → send him a reminder email
  end if
  if Participant joins **then**
    → Play informing sound
  end if
  if Meeting closed **then**
    break
  end if
end while

4 Results

Having successfully achieved the proof of concept in this phase of the project, we will now present the successful implementation along with the results obtained.

Figure 3 displays the simulation of the hardware implementation, with each step corresponding to a specific action triggered during the meeting. Step 1 illustrates the default settings. Step 2 is activated when the host initiates the meeting. Step 3 occurs when a participant joins the meeting. Step 4 represents the moment when all participants are present. Finally, Step 5 reverts to the default settings after the meeting has finished.

4.1 Qualitative Results

To evaluate the qualitative outcomes of our experiments, a detailed demonstration was executed, as depicted in Fig. 3. The demonstration commenced with the connected applications being configured to their default settings: the desktop lamp in an off state, the RGB LEDs emitting a green light, and the fan operational. In Step 2 of Fig. 3, the scenario evolves to reflect a user initiating a meeting, resulting in the desktop lamp to be turned on, the RGB LEDs transitioning to red, and the fan in operational status. Progressing to Steps 3 and 4, the arrival of all meeting participants is signified by the RGB LEDs changing to blue. Terminating the meeting prompts a return of all devices to their initial settings. Additionally, a welcome email at the start of a meeting is sent. The systems is designed to send reminder emails, complete with a link for joining, to late participants once a predetermined time threshold is surpassed. The presence of all participants triggers the AI agent to alert the host through a sound signal. The empirical results substantiate the concept of utilizing AI and IOT technology to augment the virtual meeting experience within a domestic settings. The automatic activation of the desktop lamp represents a noteworthy convenience, sparing the user from manual intervention during the meeting. The RGB LEDs (WS2812B) serve a dual function: providing ambient lighting and communicating a privacy signal to nearby individuals based on the color emitted. Thermal comfort is addressed through the fan's responsive operation, contributing to an optimized home office environment. Crucially, the automated regulation of household devices throughout the meeting demonstrates a strategic approach towards efficient resource utilization, encompassing both electricity conservation and better user experience. A significant aspect of this experiment is the integration of AI and IOT. The implementation of automated communication protocols, namely the

sending of welcome and reminder emails, plays a pivotal role in enhancing the punctuality of meeting participants. The functionality to notify the host upon the arrival of all participants contributes to a more streamlined and stress-free initiation of meetings.

In summary, the qualitative results obtained from this experiment not only validate the proposed concept but also lay the groundwork for future enhancements and innovations in this domain. The integration of this technology in home environments, as evidenced by this study, holds significant promise for enhancing the user experience in virtual meetings.

5 Discussion

The successful execution of this project has effectively demonstrated the theoretical capability to control a variety of household devices. The results underscore the wide applicability of the concept. This project is particularly beneficial for students and employees who frequently engage in virtual meetings from their home offices, as it offers significant convenience during extended sessions. Moreover, the idea is adaptable to larger-scale enterprises such as businesses and educational institutions. For instance, in the context of education, this system could be utilized in remote smart classrooms to automatically manage lighting or adjust thermal comfort by controlling air conditioning systems. A notable advancement demonstrated by this project is the potential to transform ordinary household devices into smart devices. Currently, many products offered by furniture companies do not incorporate such technological integration. Adopting this concept could encourage these companies to increase the production of smart devices tailored to consumer needs, potentially boosting sales. Furthermore, this implementation is not limited to specific virtual meeting platforms like Zoom; it is designed to be compatible with various platforms, offering versatility to the user. Alternatively, developing a standalone application of this concept is feasible, allowing for a unique brand, features, and functionalities independent of existing platforms like Zoom.

6 Work limitation

Although the implementation of our work was successful, the project at this stage still has some limitations that need to be addressed. First, it would have been advantageous to integrate a Bluetooth connection for each peripheral device instead of using cable wiring. This is particularly relevant in real-world scenarios where such devices are often apart from each other. Therefore, Bluetooth connectivity would be more convenient than cabling. Regarding the hardware design, the majority of the electronic components used were intended for educational purposes and may not be suitable for industrial production. It would have been more efficient to select components with the minimum specifications necessary for the design. For instance, in our design, we used an Arduino Uno, but only three digital pins were needed to connect our outputs. A microcontroller with fewer digital ports, such as the Arduino Nano, would have been a better choice due to its lower cost and smaller size.

7 Conclusion

In conclusion, the research successfully demonstrates an innovative integration of Artificial Intelligence of Things (AIoT) and Human Computer Interaction (HCI) in enhancing virtual meetings within home office environments. By harnessing the synergy of IoT and smart technology, the study presents a seamlessly connective solution of home peripheral devices in the meeting platform by enriches the virtual meeting experience of the user. The capability to transform conventional household devices into smart, interconnected tools paves the way for furniture and electronics manufacturers to innovate the evolving needs of the remote workforce. The contributions of this study in leveraging AIoT for enriching virtual meetings are not just a reflection of technological advancement but also a step forward in adapting our living and working spaces. Future directions for this work could include integrating computer vision recognition to detect various actions during meetings, such as sleeping and distraction. The system could then notify users and alert them through notifications and alert devices.

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