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ABSTRACT

The COVID-19 pandemic has presented many challenges to employees in every sector by forcing them to work remotely. Office working seems an unusual concept as everyone has had to readjust their lifestyles and working patterns to allow a working from home approach, alongside maintaining a work-life balance. This paper contributes with a prototype where working from home is re-imagined in a post-pandemic world. We explored the use of smartwatches to support the well-being of software developers. A human-centred design approach drives the prototype and evaluation. This paper relies on the User-Centred Design Framework. Data affinity analysis showed that isolation is a paramount problem for software developers working from home. Results show that all the participants involved in the study experienced the feeling of isolation while working from home, some being more extreme than others. While this solution focuses on a particular population, given that smartwatches have become more affordable and ubiquitous, this solution could benefit different types of office workers regardless of the type of work, socioeconomic status, or nationality. This paper investigates the use of smartwatches and virtual reality to support the wellbeing and isolation of people.

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INTRODUCTION

Remote working has been a common and adequate solution for software developers during the COVID-19 pandemic, due to the highly collaborative nature of the job, it has been reported (Bernaerts *et al.,* 2014) that their mental well-being has been affected due to being isolated at home. Working in an office allows for freedom of movement and communication with colleagues to work in a more efficient and organised way. Whereas now, planning meetings or work sessions take an additional number of steps via online tools (e-mail, polls, etc.) to suit the availability of the members of the team.

Over a year into the COVID-19 pandemic, companies have settled into working from home. Employees are experiencing the benefit of having flexible working schedules allowing time to spend with their family and friends while completing their work to deadlines. On the other hand, some project managers require employees to have video calls through platforms like Zoom with cameras to ensure productivity and to keep on top of their employees. Thus, in addition to the typical daily job pressure, software developers could feel under pressure to perform well and feel surveilled, affecting their wellbeing.

Smartwatches from different manufacturers (Apple, Samsung, Fitbit, etc.) integrate several useful sensors, such as an accelerometer, gyroscope, heart rate, blood oxygen monitor, and an altimeter. These sensors can provide functionalities like the number of steps walked, sending hourly reminders to stand up, quality of sleep, level of activity and heart rate, etc. (Hernandez *et al.,* 2021). Moreover, information like mobility or if users are in a workspace for a certain amount of time can be used to infer normal and abnormal wellbeing, isolation levels, and productivity.

This paper presents a solution based on the use of many of the functionalities of smartwatches to support the well-being of software developers. This system could be of benefit to other types of office workers around the globe. Thus, while the approach presented has been designed and evaluated considering the needs and concerns of software developers in Northern Ireland, given the constant progress of the software development industry around the world, we think this solution would be feasible and of great benefit in a global context. The remainder of the paper is organised as follows. Section 2 presents the related work on the use of

smartwatches to support the wellbeing of software developers and the use of VR work platforms. Section 3 describes the participants that supported this study. Section 4 presents a design of the proposed solution based on the objectives and the functional requirements identified by the participants. Section 5 describes an initial prototype of the proposed solution. An evaluation and results are presented in Section 6. Finally, Section 7 offers conclusions and future enhancements.

RELATED WORK

To our best knowledge, the use of smartwatches to reduce isolation, and support the wellbeing and productivity of software developers and office workers, in general, has not been as widely investigated as the use of smartwatches to improve fitness and general wellbeing.

Beh *et al.* (2021) presented a study using the Unified Theory of Acceptance and Use of Technology (UTAUT2) combined with perceived vulnerability and perceived severity as moderators with a cohort of 271 participants. They reported that the use of smartwatches for health and fitness monitoring could motivate people to follow a healthy lifestyle and detect early stages of chronic diseases. In (Auepanwiriyakul *et al.,* 2020), the accuracy and the acceptability of wearable motion tracking smartwatches for inpatient monitoring were investigated with a cohort of 44 hospital patients and 15 hospital staff members. In the results reported by Auepanwiriyakul *et al.* (2020), participants agreed that smartwatches are user-friendly, comfortable, unobtrusive, suitable for prolonged use, and do not cause anxiety.

Weiss *et al.* (2019) presented a study considering biometrics (accelerometer and gyroscope) from a smartphone and a smartwatch in the context of 18 Activities of Daily Living (ADLs), which included: walking, sitting, typing, and writing. Monitoring ADLs can support the detection of abnormal behaviours that could indicate an emergency or a gradual health decline. Some of the ADLs considered in (Weiss *et al.,* 2019) are relevant and frequently occur in the context of office workers. Smartwatches have also been considered for health monitoring during the COVID-19 pandemic. Quer *et al.* (2021) investigated the use of data collected from a smartwatch and self-reported symptoms for COVID-19 detection. The results reported in (Quer *et al.,* 2021) indicated that combining symptom and sensor data provided an Area Under the Curve (AUC) value of 0.80 for discriminating between symptomatic individuals who were positive or negative for COVID-19.

The use of smartwatches in an office environment has also been investigated in the literature. Bernaerts *et al.* (2014) presented the develop-

ment and design of a smartwatch app to digitally augment interactions commonly performed in office environments, like locking or unlocking doors or obtaining information about rooms. In (Bernaerts *et al.,* 2014), smartwatch functionalities focused on interacting within an office environment to support productivity rather than to reduce isolation or support the wellbeing of office workers.

In (Mekruksavanich *et al.,* 2018), a study about Human Activity Recognition (HAR) using a smartwatch to detect sitting to identify Office Workers Syndrome (OWS) was conducted. OWS is characterized by sitting or remaining in the same position for long periods. Results reported in (Mekruksavanich *et al.,* 2018) achieved an accuracy level of 93.57% for activity recognition when sitting. The study presented Ren *et al.* (2018) investigated Peer-based Cooperative Fitness Tracking (PCFT) to encourage physical activity among office workers. In this case, Ren *et al.* (2018) used a fitness tracker rather than a smartwatch, but the sensors used can also be found on smartwatches of different makers. Ren *et al.* (2018) reported that this type of fitness tracking in office workers might improve awareness of physical activity, support a healthy lifestyle, and facilitate fitness breaks during daily work.

The use of VR in the work environment is becoming increasingly popular. Many companies worldwide have employed the use of Virtual Reality platforms and equipment to enhance the work experience for employees, especially in the sector of IT, which is under investigation in this report. Hubs is an online work platform where you can create an avatar of yourself that others can see and use by engineers at Nottingham University. It was accepted widely and allowed people to create an online version of themselves. Ellie Gibson, a games journalist who loves this concept, says, *"I wouldn't want to be myself, a 43-year-old woman from Catford."* (Ramachandran, 2021). This sparks a debate as to whether there is an expectation of representing oneself and maintaining a professional profile while online. Depending on the workplace one is in, one must adapt to its culture and environment. This platform would be beneficial in the technology, design, or architectural sector; however, it is argued that it would be inappropriate in other business areas, such as social work and the legal industry. This is due to the serious nature of the work and the need to conduct themselves professionally to make a case that needs to be taken seriously. Virtual reality has the potential to transform how work is carried out and how social interactions take place among colleagues, clients, and businesses.

The problem of isolation amongst remote office workers has also been considered in the literature (Marshall *et al.,* 2007; Hickman, 2019; Bell, 2020), although to our best knowledge smartwatches have not been

used to detect or reduce isolation in office workers. Quintero (2019) presented a study about facilitating technology-based mental health interventions with mobile virtual reality and smartwatches, which in terms of the types of technologies used is the closest to our approach. However, the approach presented by Quintero (2019) does not focus on office workers, in particular, hence the novelty and relevance of the presented approach.

PARTICIPANTS

The proposed solution in this paper is driven by the data collected and analysed from a set of participants who agreed to take part in this investigation. As the chosen topic was work and more specifically software development work, 5 participants were selected from the IT company Allstate. 2 women and 3 men were selected from the ages of 19 to 40. To eliminate any bias, the participants belong to different areas of this global company, as well as one participant being located in India. We felt this participant would be able to give valuable insight to the company which others have not experienced before. Also, different levels of workers were chosen, from entry-level apprentices and recent graduates to people who have worked in the industry for over 10 years. This varied cohort ensured the data would be fair and give a broad variety of answers capturing the big picture and allowing this investigation and solution to be aimed companywide, not just at specific workers. Each participant volunteered to be part of a study with consent letters being signed confirming they were comfortable to have their answers recorded and featured in a research paper.

DESIGN OF SOLUTION

To come up with a solution, the User-Centred Design approach was used. Semi-structured interviews took place with each of the 5 participants. A set of questions were asked relating to their experience working in the IT industry and specifically how they found working from home and what their company did to aid them during the challenging times of COVID-19 which we as a global population were presented with. From the information gathered at this stage, it was transcribed, and quotes were extracted and placed into an Affinity Diagram (Lucero, 2015). This allowed for a breakdown of the important issues raised: Isolation, Convenience/Comfort, Productivity, and Teamwork. The weighting of each heading is as follows: (i) Isolation: 35%, (ii) Comfort and Convenience: 25%, (iii) Productivity: 20%, and (iv) Teamwork: 20%.

At the end of this stage, it was clear there was a concerning number of comments relating to employees feeling isolated from their teams (12 out of 35 quotes) and struggling with their micromanagement. Below are a few quotes taken from the Affinity Diagram which pointed to the main topic for concern as Isolation.

- "The hardest part is the difficulty in forming personal relationships with members of the team, as face-to-face interaction, even though virtual means is limited."
- "It can be hard to stay focused and on task as there is no one at the desk beside you to help you out immediately"
- "The hardest part has been the transition from social environments to one that is virtual and quite isolated."
- "I've found it hard to integrate with teams or feel connected to the business"

The next step was to use the data gathered and create *"The Big idea"*. This is when a solution was brought forward addressing the problems which were presented during the interviews:

- Find a way to limit the feeling of isolation while working remotely.
- Look after employee wellbeing including mental health.
- Promote networking between employees in a virtual environment.

The proposed system involves multiple technologies: mobile applications, Virtual Reality, Artificial Intelligence, and wearable sensors. The purpose of the system is to measure stress and anxiety through heart rate, blood pressure (Lee *et al.,* 2021), and motion sensors. The users' sleeping habits are also recorded to define a resting heart rate and blood pressure to allow a machine-learning algorithm to calculate when the statistics given by the sensors are at a point for a prolonged period. The system then recommends the user to take a break and join a social break-out room which is on a VR Platform. The data flow diagram of the system and a prototype are presented in the next subsection. The prototype was an initial way to represent this concept visually and present it in a smartwatch and mobile dashboard application. Although it is impossible to give an exact number or figure of how much stress a person is under or how isolated they are. With the use of sensors measuring variables which research has been undertaken to infer these feelings and validate them, therefore we have created a complex approach to give an overall reading, relying on heart rate, blood pressure, and motion sensors.

SYSTEM ARCHITECTURE

Before creating a digital prototype to represent the proposed solution, an architecture and data flow diagram were designed to give high-level insight into what would be involved in the system. From employees in a private company, it shows their journey and each stage that happens when using this technology. Another way to describe this architecture is a data flow diagram (Ibrahim, 2010). This is where the user can visualize the system model (see Figure 1).

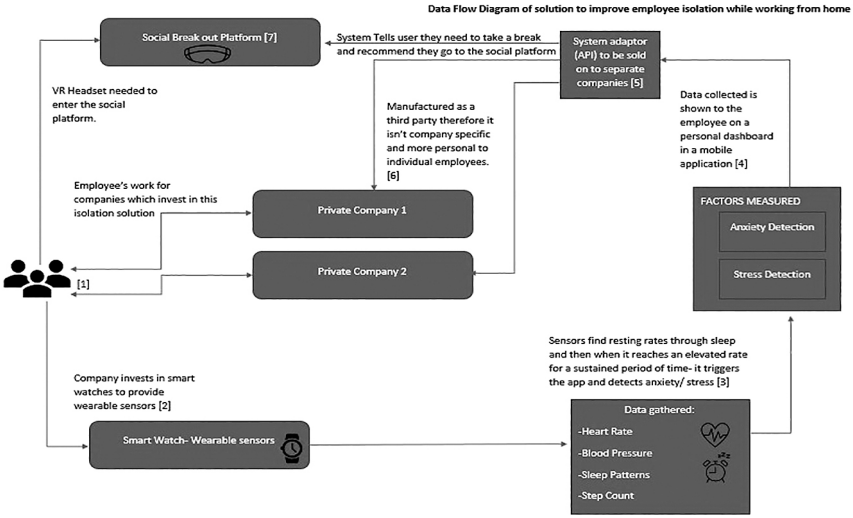

Figure 1. Data Flow diagram of the isolation system.

PROTOTYPE

To complement the system architecture diagram, included are the prototype screens created, which relate to these elements explained above. Starting with the smartwatch, move onto the dashboard app which shows more detail of measurements taken and displays the trigger warning. They are in order of how the data flows around the system (see Figure 2).

To demonstrate a users' pathway through this system, 2 scenarios were presented to participants in a focus group to receive feedback. The first scenario is included in this paper and was as follows:

"Jack is a software developer working in NI for Allstate. With the global pandemic of COVID-19, all employees had to move to remote working. This has continued for over a year, and he is struggling with feeling isolated from his team, which has taken a toll on his mental health and he

Figure 2. Prototype Screens- Following the architecture.

is looking for a way to feel less isolated and separate from the company while working from home. Allstate invested in this technology and Jack has been one of the employees who signed up to avail of the service. While working for a long period he received a trigger alert on the mobile application detecting that he is stressed due to elevated blood pressure for a prolonged period. The app has recommended that he joins the social room for some relaxation time. He took this opportunity to head to the library to read and have some quiet time."

EVALUATION AND RESULTS

Once we showed the prototype and presentation of user stories to the focus group, they gave feedback which would allow us to further develop this idea in the future to include and broaden the spectrum of this project. We gathered opinions on whether the participants thought we had accurately interpreted their responses from the initial interviews and come up with a solution that addressed their concerns and would be beneficial to implement into corporate companies. A System Usability Scale (SUS) survey was conducted where each participant gave a score out of 5, with 1 being strongly disagreed and 5 being strongly agreed for pre-set questions. The results from this are presented in Table 1.

USER	SUS SCORE	PERCENTAGE	GRADE
1	37	92.5	A
2	33	82.5	B+
3	38	95	A
4	33	82.5	B+
5	35	87.5	A-

Table 1. Results of SUS survey.

All the participants felt like this solution has captured the problem and given a very good solution to cope with isolation while working at home. We believe this solution will aid employees of corporate companies where it is easy to sometimes feel lost and insignificant in the big scheme. This allows employees to gather and become more familiar with each other and would be a good way to do team-building events. All participants said they would be happy using all technologies and think company-wide, it would have a great uptake and has many advantages. From looking after employee wellbeing to ensuring working from home is less isolated and incorporating many features to create a wide variety of applications that would suit any age and ability.

Below are some comments that were given during the feedback session:

- "It's the best way to sense behaviour in a non-invasive manner."
- "It is best to only wear the watch Monday to Friday and not the weekends as to not be monitored 24/7 as their sleep patterns on the weekends can be disruptive with other plans."
- "Great idea to make a different break-out room instead of one generic place as it would help to facilitate conversations depending on where you are. E.G has a book club in the library section where people can talk and share common interests."
- "Having this technology to improve meetings for teams would be great, makes it more realistic and interactive."

The final comment from a user was: *"This can change people's lives for the better- monitor mental health/ wellbeing all while allowing employees to make friends not just have colleagues."* From this quote, we felt it was proven that our solution was appropriate and would certainly impact those who are affected by isolation. When reviewing the solution, as developers we acknowledge that many could find this solution to have ethical implications. Due to the employee monitoring and creating reasons for a company to end contracts due to an employee being in bad health. Buying into this solution is at the employers' discretion to use as they wish, however, the intended purpose is to be a personal choice and to aid personal development just in a business enterprise environment. As there is no way to put a figure on how a person feels, the use of biosignals is the closest way which currently is available to indicate isolation and stress. The WHO (Baumann *et al.,* 2010) indicated the worksite is one of the priority settings for health promotion in the 21st Century. In addition, the setting and social network of the workplace is considered to have a potentially large reach of individuals, resulting in a high ex-

pectation of health promotion in an occupational setting. Each company will have its policy on employee wellbeing and how they show a "Duty of Care" to each employee. In recent years there has been an emphasis on mental health in policies, and dedicated strategies that are used to combat mental health issues (Goh *et al.,* 2015). This solution is a voluntary approach and could be an initiative within a company to promote networking and potentially improve employee satisfaction within the workplace.

CONCLUSION

This paper introduced a new idea to help workers in the IT sector cope with working from home in a long-term situation. Many companies have decided to introduce a hybrid model where office working is blended with remote working. The advantage of this has more flexibility; however, on the downside, employees feel isolation has taken a toll on their mental health and wellbeing. The proposed solution allows for monitoring employees and helping them deal with anxiety and stress and making recommendations to ensure the wellbeing and mental health is at the forefront and a priority to businesses. Following the User-Centred design model, it was possible to conduct interviews, focus groups, and design system architecture and initial prototypes of this idea to improve the interaction between humans and computers. This isolation and wellbeing technology promotes social interaction by transforming the way software engineers work from home. This smartwatch, app, and VR setup consider developers' needs and requirements, which is to collaborate on a large scale for some projects down to paired programming. Although technologies already exist to detect bodily functions such as heart rate, blood pressure, and sleep patterns, the proposed approach makes use of all the above. It incorporates the emerging technology of VR and AI, which many software developers are keen to be a part of. Thus, it allows them to get first-hand experience using this technology and not just developing it. Future work will involve branching, being innovative, and keeping the focus on the user, and, as they change, updating the technology to keep up in an ever-evolving world of IT where nothing is ever permanent.

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