A Mobile App to Help People Affected by Visual Snow

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Abstract. Visual Snow Syndrome is a neurological disease that causes flashing dots to appear throughout the visual field. Patients claim to see an endless stream of flashing dots throughout their visual area. Although patients frequently experience concurrent migraine, visual snow appears to be a distinct phenomenon from prolonged migraine aura. VSS has been linked to eye illness, thalamic dysfunctions, pure cortical phenomena, and disturbing connections between optical networks and nervous system networks. Any process may interact with or be causative of various symptoms and clinical aspects associated with VSS. The pathophysiology of Visual Snow Syndrome (VSS) and its likely location are currently being debated. In this work, the goal we have set as a team is to create an Android software application capable of representing what people with Visual Snow Syndrome perceive. The aim is to help patients to describe (and even show) the symptomatology of their problem to their doctor. That may be a non-trivial problem since sharing with somebody the shapes, the colours, and the movement of artefacts due to VS-related pathology(s) is a highly complex and, in some cases, frustrating task since this pathology is still little known.

Keywords: Augmented reality · Eyes disease · Visual Snow Syndrome · Unity

1 Introduction

Visual Snow Syndrome is a chronic condition that has only been described and studied in recent years. Its sufferers have a visual impairment in which tiny dots of light are superimposed on the perceived image, which is difficult to describe and explain. Generally, the image perceived by these patients is described as that obtained with an incorrectly tuned television setting. In addition to the ether's information content, we get a partial snow effect.

O. Gervasi et al. (Eds.): ICCSA 2022 Workshops, LNCS 13382, pp. 473–485, 2022.
https://doi.org/10.1007/978-3-031-10592-0_34

In this article, we propose an application realised through modern Virtual Reality and Augmented Reality technologies that allow simulating the vision of people affected by Visual Snow. The advantages of this application are twofold. The first is from the patients' point of view: it gives people the possibility to show doctors or family members what their eye sees, overcoming the language barrier that makes it difficult to explain the problem. Consequently, misunderstandings can be avoided. The second is from the doctors' point of view: thanks to a mobile app, they can ask the patient to confirm if the image they perceive is similar or the same as the one shown by the software. The development of this project is carried out using the Unity[1] software, and the target environment is the Android operating system. In the Sect. 2 the most recent literature addressing the Visual Snow problem is discussed. In the Sect. 3 the steps and techniques used for the realisation of the Mobile Android application are illustrated. In the Sect. 4 the first evaluations and opinions expressed by the users of the application are reported. In the Sect. 5 outlines the main objectives obtained after the development of the mobile app and anticipates the future developments.

To try to provide help to people who have this type of condition, we have outlined the following research methodology. First of all we will make an Android application so that we can reach a large percentage of users in a very short time. After the release of the application we want to collect as much feedback as possible from people. After a subsequent phase of the improvement of the application, which will come as a result of the feedback received in the previous phase, we want to proceed with the creation of a series of anonymous questionnaires with which to collect opinions and specific and detailed feedback from users. What we want to outline is a development path that will not end with this article, but will have to proceed along a period of a few months in order to improve the application as much as possible.

2 Related Works

Visual snow is a neurological issue portrayed by a constant visual unsettling influence that involves the whole visual field and is depicted as tiny gleaming flecks similar to old detuned TV [1]. Notwithstanding static, or 'snow', impacted people might encounter extra visual side effects like visual pictures that continue or return after the image has disappeared, aversion to light, unique visualisations from inside the eye and hindered night vision.

The causes of visual snow in patients are still relatively obscure. The average age when the visual snow appears for the first time in the subjects seems, by all accounts, to be more premature than numerous other neurological problems [2]. This initial phase is almost always accompanied by a general lack of recognition of the pathology by specialists; this means that it is still an uncommon question.

Research suggests that visual snow is a mental problem; a preliminary examination of functional cerebrum imaging [3] and electroencephalographic tests propose this interpretation [4].

[1] https://unity.com/.

Visual snow is a physical condition, most often exceptionally disabling, that emerges suddenly and is highly complex to diagnose and treat [5]. That is due to the fact that it is still an open field of study: there is little much-targeted research on the phenomenon and those that do exist need to be reviewed and synthesized [6].

In 2013 the first categorization of visual snow as a new precise phenomenon was first published [7]. The authors begin with a description of a Pediatric patient who has suffered from migrainous headaches since the age of seven. The patient had an unexpected beginning of chronic visual impairment. Subsequently, data began to be collected over several years on patients complaining of a reasonably homogeneous set of symptoms suggesting a single common syndrome [8].

Most patients developed migraine, and many exhibited the classic migraine aura, indicating an overlap of illness processes [9]. However, the study highlighted that one of the significant reasons for patients' suffering was the persistent and relentless visual snow symptoms, which lack the episodic aspect characteristic of migraine [10]. Furthermore, only a minority of research participants experienced a visual aura at the outset of Visual Snow Syndrome, indicating that visual snow is distinct from chronic migraine aura. The connection between migraine, typical migraine aura, and Visual Snow Syndrome has been studied further. It was discovered that individuals with Visual Snow Syndrome and simultaneous migraine experienced more different symptoms [11].

Moreover, the role of visual cortical excitability in visual snow has been investigated [12,13] using visual-evoked magnetic field recording in individuals with persistent visual disturbance [14]. Some recent studies show how the VSS can appear as a result of traumatic events that affect the brain, for example explaining how a patient has manifested the disease following a cerebral infarct [15].

In conclusion, we have to admit the aetiology of visual snow is still unknown, and more research with precise criteria and control survey respondents suited for migraine and typical migraine aura is needed to better our understanding of this painful illness. Because of a lack of comprehension of the syndrome's core biology, there are no therapeutic techniques that are significantly successful.

While there is plenty of scope for research from a clinical point of view, our proposal fits into a virtually new segment in terms of applied technology. There is a great deal of work using automated solutions for disease recognition [16–18] and many others using virtual and augmented reality for diagnosis and rehabilitation [19–22]. Virtual reality is becoming an increasingly important technology in the generation of synthetic environments [23] within which therapists and patients can move easily, making everything extremely customisable. In addition, the extreme level of refinement in image definition achieved today [24,25] and the high usability of content in mobile device apps [26,27], especially in the clinical and medical fields [28,29], indeed allows for sophisticated and innovative techniques for describing a patient's symptoms.

3 The Visual Snow Simulator

This section describes the proposed application to simulate what people with Visual Snow see. The mobile app is built using the Unity software. Unity is a software for the creation of multi-platform interactive environments. It is often used to create video games, virtual reality scenarios or augmented reality scenarios [30–33]. We have set Android 11.0 (API 30) as the target environment and Android 5.0 (API 21) as the minimum supported version. That allows the application to be installed on 98.0 % of the Android devices currently in circulation, as shown in Fig. 1; the data shown in the figure are released by Google annually. The software has been developed to be compatible with the ARM64 and ARMv7 architectures, 64-bit and 32-bit, respectively.

ANDROID PLATFORM VERSION		API LEVEL	CUMULATIVE DISTRIBUTION
4.1	Jelly Bean	16	
4.2	Jelly Bean	17	99,8%
4.3	Jelly Bean	18	99,5%
4.4	KitKat	19	99,4%
5.0	Lollipop	21	98,0%
5.1	Lollipop	22	97,3%
6.0	Marshmallow	23	94,1%
7.0	Nougat	24	89,0%
7.1	Nougat	25	85,6%
8.0	Oreo	26	82,7%
8.1	Oreo	27	78,7%
9.0	Pie	28	69,0%
10.	Q	29	50,8%
11.	R	30	24,3%

Fig. 1. Android platform distribution - November 2021

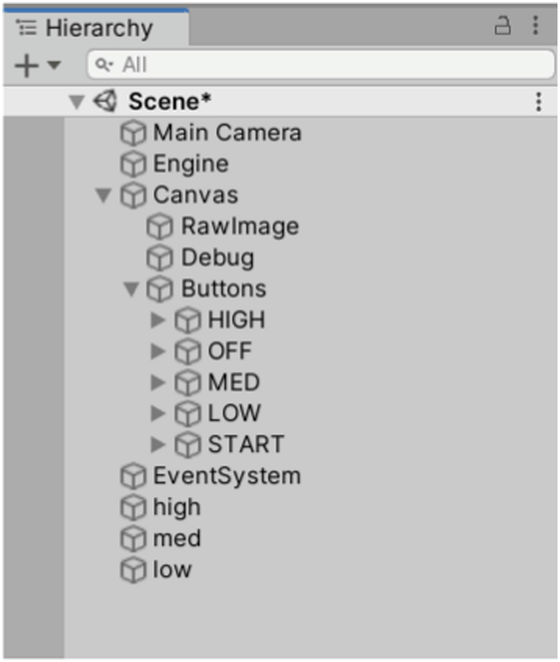
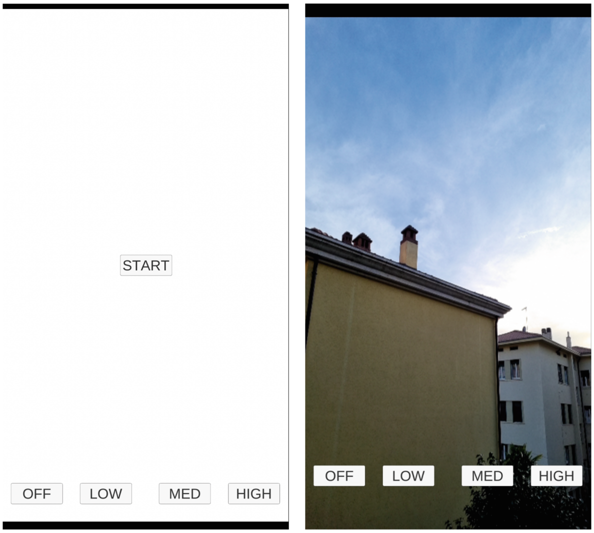


Fig. 2. Scene composition of the software

Figure 2 shows the list of Game Objects that compose the software. The first element is the *Main Camera*, its task is to capture images and show them on the user's screen. This should not be understood with the smartphone camera, but instead as a virtual camera inserted inside a Unity scene. The second Game Object is called *Engine*. Some scripts are connected to it, such as those that are executed when buttons are clicked, and it is used to manage the user interface. The third object is the *Canvas*, which represents a graphical drawing environment, on which the buttons and the whole user interface are placed. Inside the *Canvas* we can see that there is an object called *RawImage*. This is used to apply a background to the canvas. In our case the background applied to the *RawImage* (and consequently to the canvas) is the image captured by the smartphone camera. The video stream is managed by a script that periodically updates the image shown on the screen, giving the idea of a smooth view of the world captured by the camera. The buttons that make up the graphical interface are collected within a container that allows a simplified management from a programming point of view. Inside the scene we find the *EventSystem*. This is used for the recognition of user input, such as clicks on the screen. Finally, there are 3 Game Objects called *high*, *med*, and *low* that are the basis for the activation of filters that simulate the Visual Snow. These Game Objects are passed by reference to the Game Object *Engine* which will use them to activate the on-screen effects based on user input.

The initial screen, which appears on the screen, is shown in Fig. 3a.



(a) (b)

Fig. 3. Starting screen of the mobile app (**a**), Camera without Visual Snow effect (**b**)

The *START* button is in the centre of the scene, which, once pressed, will activate the user's smartphone camera. The application is programmed to ask for permission to access the API that controls the camera if necessary. If the user responds affirmatively, the captured image will be shown on the screen, as shown in Fig. 3b.

The buttons at the bottom of the user interface are needed to activate or deactivate the effect simulating Visual Snow. After careful consideration, we have programmed three different effects. The button *LOW* presents a barely perceptible Visual Snow effect and tries to simulate what a person sees when his pathology is not particularly serious. The *MED* button, when pressed, activates a much more intense effect than the previous one. The *HIGH* button sets the Visual Snow effect on screen at an extremely high intensity. The *OFF* button deactivates the Visual Snow effect (Fig. 4).

The technical realisation of these effects takes place thanks to the use of the *Post Process Volume*, which allow the insertion of graphic effects that are calculated at the end of the pipeline that manages the rendering of the scene. For each button used to activate an effect, we have programmed a specific Post Process Volume. Inside each Post Process Volume, we inserted a graphic filter of the Grain type. We found it particularly effective to simulate Visual Snow to use a filter of this type. Initially, the Grain filter is programmed to mimic what is captured by old cameras that use chemical photographic film to capture images on film and add video noise to the scene by their nature. The Grain filter

(a) (b) (c)

Fig. 4. Different Grain filter levels set on screen (**a**) low mode, (**b**) medium mode, (**c**) high mode

can be configured thanks to four different parameters that the developers can adjust. The first parameter is a Boolean variable called *Colored* which allows us to define whether or not the grain effect should be coloured. The second parameter is called *Intensity* and allows us to define the number of particles to be shown on the screen. The third parameter is *Size* and allows you to define the size of the particles shown on the screen. The fourth and last parameter is the *Luminance contribution* which is used by the graphics engine to modify the effect according to the brightness of the scene and to reduce its intensity in poorly lit areas. An example of how the filter has been configured for the medium intensity configuration is shown in Fig. 5. The application was developed taking into account Android's best practices. In fact, the latest versions of the operating system require to inform the user before accessing the camera or microphone. In the absence of informed consent from the user, mobile applications will not be able to use these devices. The first time the program is launched, the user is asked to authorise or not the use of the camera, and only after the user's authorisation can the program run correctly. Regarding the compilation and export phase of the application, we have used the App Bundle format instead of the old APK format as required by Google from August 2021. The final size of the app is 12 MB, which makes it possible to install the program even on devices that have minimal amounts of ROM memory. Finally, we made several measurements to estimate the minimum RAM requirements that the smartphone must have. From our tests, we found that the average RAM usage is 32.0 MB.

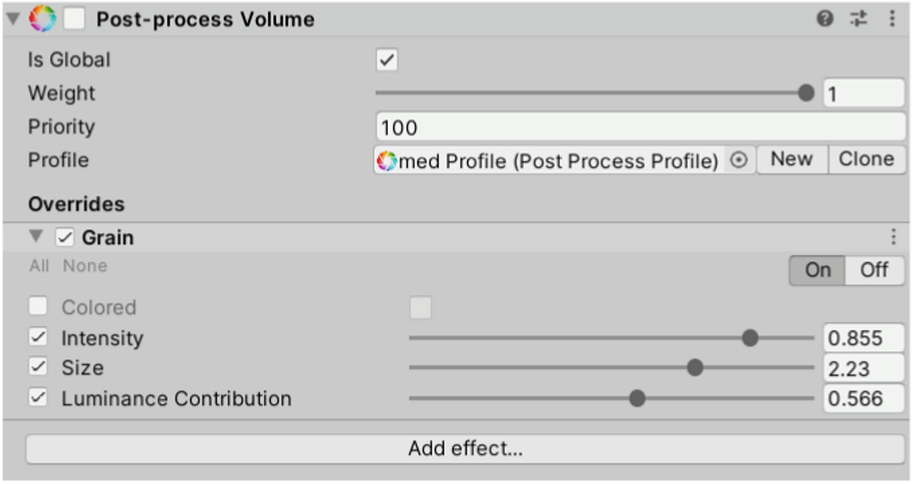


Fig. 5. Post-process Volume with Grain effect on medium settings

4 First Impressions

In this section, we report the first evaluations and opinions expressed by the users of the application. The application was made available on the Play Store on February 12, 2022. During this period of time, we detected a large flow of downloads. Many users downloaded the application from the Store.

Figure 6a shows the distribution of Android versions used by users who installed the application. As we can see, the most recent versions of Android are the most popular ones, and this parameter is in agreement with what is indicated by Google and with which we produced the graph shown in Fig. 1. Figure 6b shows the distribution of installations by geographic area, and the countries that have installed the application are shown in a pie chart. As can be seen from the figure, the greatest diffusion took place in the United States and Italy. This is probably due to the fact that the message with which we have informed people about the presence of this application in the Store has been inserted in a group composed mainly of people living in the United States.

In Fig. 7 is shown the trend of downloads from the date of publication of the application. As we can see, the growth is steady, moreover there is a peak of downloads in correspondence on March 25, the day on which we mentioned the application with a post on Facebook.

During this time period, we received many ratings that people spontaneously made within the Google Play Store and also we received several email messages from people suffering from this condition. Regarding the ratings, we got 11 reviews and all the reviews were 5 stars as shown in Fig. 8. The comments made to us are mainly of appreciation towards the work we have done. As for the suggestions, we got some very interesting ones. For example, a user asked us to implement a feature that allows us to manually set the level of Visual

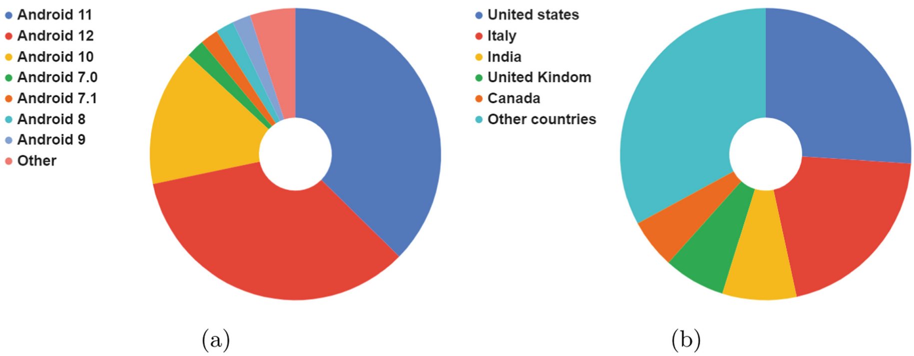


Fig. 6. Distribution of the installations across Android versions (**a**), Number of users using the application (**b**)

Snow simulated by the software, because his case did not find correspondence in the three levels we preset. The problem of this patient was characterised by an intensity lower than what we have set as "low level". This is surely a very important aspect and we will try to satisfy this request with further updates. Other suggestions concerned the possibility of making the pixels representing the Visual Snow coloured or black and white. Finally, some users have asked us to create the same application for the iOS platform as soon as possible because they are owners of iPhones and, therefore, can not install the program that, by design, is programmed to work only on Android.

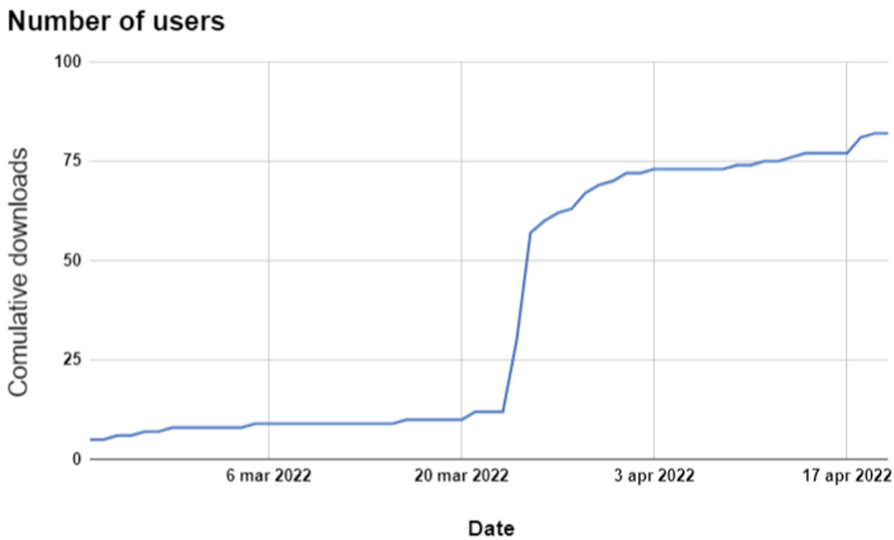


Fig. 7. Number of users using the application

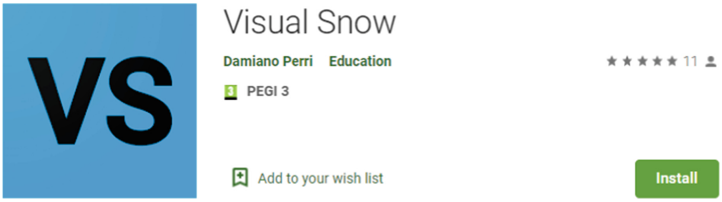


Fig. 8. The mobile app in the Store

5 Conclusions and Future Work

This work aimed to create an Android software application capable of representing what people affected by Visual Snow Syndrome perceive in a simple and effective way. The application has been published on the Play Store and can be freely downloaded from any device with at least Android 7.0. The code produced during the development of the application has been made Open Source and made available to the scientific community through GitHub[2]. A short video showing the application running has been uploaded to YouTube and is publicly available[3]. We are very interested in continuing this project and analysing further developments for the application. The first goal is to make the application cross-platform, i.e., expand its compatibility with the iOS operating system and allow iPhone and iPad users to use it. A second objective is to analyse the opinions of doctors and patients suffering from Visual Snow. For this reason, we are planning to carry out a series of anonymous questionnaires to collect data that will allow us to improve the application. Moreover, hopefully, it will help people suffering from this pathology explain their problems better and better and help doctors get adequate information from patients quickly.

Acronyms

The following acronyms are used in this manuscript:

API	Application Programming Interface
APK	Android Application Package file
AR	Augmented Reality
ARM	Advanced RISC Machines
MB	MegaByte
RAM	Random Access Memory
ROM	Read Only Memory
VR	Virtual Reality
VSS	Visual Snow Syndrome

[2] https://github.com/DamianoP/VisualSnow.
[3] https://youtube.com/shorts/cl_SAjyGY64.

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