A New Exercise Environment for the Experimental Treatment of Visual Snow

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Abstract. The Visual Snow Syndrome is a neurological condition that causes flickering dots to appear across a person's entire field of vision. Those who suffer from this syndrome report seeing an unending stream of flickering dots throughout their visual field. Although patients often experience concurrent migraines, Visual Snow Syndrome appears to be a distinct phenomenon from prolonged migraine aura. The cause of this syndrome is not yet fully understood, but it has been linked to various eye and brain dysfunctions. The aim of this work is to make improvements to the environment in which exercises affected by this condition are developed. Currently, the Visual Snow Initiative provides an online platform where it is possible to carry out a 30-day exercise cycle during which patients are shown videos with noise that simulates Visual Snow and only affects certain areas of the visual field. This video noise moves and shifts along the screen occupying different areas of the screen. The video stream is sent from the servers to the users and requires a modern and efficient internet connection. A single video file occupies about 2GB of disk space. Modern codecs that deal with compressing video and encoding it into browser-supported formats have great difficulty encoding a stream where the pixel matrix of the video is in constant motion. The purpose of this work is to reconstruct the noise that is displayed within the video files for the exercises by means of JavaScript algorithms in such a way as to reduce the download required from users to a few kilobytes and to generate client-side the video that will then be used for the exercise.

Keywords: Augmented Reality · Eyes disease · Visual Snow Syndrome · Web Programming

1 Introduction

For some years now, researchers have been focusing on the study of a chronic condition called Visual Snow. Visual Snow is a visual pathology that affects a small

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but significant percentage of people worldwide. Characterised by the perception of a constant visual disturbance, similar to television noise that appears when the antenna is not properly tuned. Visual Snow can be extremely disabling for sufferers. The condition is characterised by bright spots, sparkles, mists and lines moving within the visual field. These symptoms can cause severe visual discomfort, interfere with daily activities and impair patients' quality of life. Currently, there is no definitive cure for this condition and available therapies mainly focus on symptom management. An innovative approach being tested today consists of a 21-day cycle where the patient has to watch 30-minute films showing video noise. This is also described on the official page of the Visual Imagery Project (VSP)[1]. It is important to point out that VSI is an experimental treatment and its efficacy rate is still a matter of scientific investigation.

The idea is that these films help patients focus their attention on the external visual stimulus and reduce the perception of internal visual disturbance. However, this therapy has some limitations. First of all, it requires a large video stream, which means that patients must have access to a fast and stable internet connection in order to benefit from the therapy. In addition, video streaming can consume a significant amount of data, which could be a problem for patients with bandwidth limitations. In this article, a new approach for the treatment of Visual Snow will be presented, based on the generation of video noise through a client-side JavaScript code. To overcome these limitations, we propose an improvement to the experimental approach currently used to treat Visual Snow. Our approach is based on generating video noise through a client-side JavaScript code. The code can be downloaded and executed within the user's browser, and does not require real-time video streaming, greatly reducing the amount of data required to utilise the treatment. This method is intended to contribute to the valuable work carried out by the Visual Snow Initiative[2], which consists of feeding users films with video noise moving across the visual screen. The goal is to reduce the amount of data needed to deliver the videos with visual noise to patients, eliminating the need for a large video stream. This will reduce loading times and the amount of data to be downloaded, simplifying access to therapy for anyone who needs it.

In this article, we will detail the development process of our JavaScript code, the experiments conducted to test its effectiveness, and the potential future applications of this technology for the treatment of other similar visual pathologies. With our proposed JavaScript code for client-side video noise generation, we hope to offer a new and improved therapy for Visual Snow patients. Section 2 the most recent literature addressing the Visual Snow problem is discussed. Section 3 the steps and techniques used for the realisation of the JavaScript code and the application are discussed. Section 4 outlines the main objectives obtained after the development of the mobile app and anticipates the future developments.

[1] https://visualsnowproject.com/.
[2] https://www.visualsnowinitiative.org/.

2 Related Works

This section reviews the modern scientific literature dealing with Visual Snow pathology.

According to epidemiological and clinical studies, VSS is linked to other perceptual disorders such tinnitus, fibromyalgia, and vertigo. There may be clinical similarities and pathophysiological analogies in migraine [1]. The clinical characterization of visual snow syndrome is currently undergoing development, with proposed modifications to the diagnostic criteria. Two recent studies have investigated the possibility of dysfunctional visual processing and hyperexcitability in the occipital cortex through the use of electrophysiology. Additionally, advanced functional imaging techniques show potential for providing more detailed understanding of the underlying disease mechanisms [2,3].

In some individuals, their keen observation skills allow them to perceive their own white blood cells flowing through the retinal microvasculature, appearing as small cells or dots moving in a squiggly path, particularly when observing the blue sky. This phenomenon is referred to as the blue field entoptic [4,5] or Scheerer's phenomenon and can be elicited using a blue field entoptoscope. Research indicates that this phenomenon is present in up to 80% of individuals with visual snow [6].

Modern technologies can, in our opinion, contribute to helping people with this condition. Augmented Reality (AR) and Virtual Reality (VR) [7,8] are also increasingly being used in the medical field, and science is discovering potentials that were not even imaginable a few years ago [9]. In this article, a mobile programme for Android is proposed that allows one to simulate what people with Visual Snow see [10].

The recent experience we all had with COVID-19 made it clear that new technologies are essential [11–13] and should be used as much as possible to improve people's quality of life. Artificial intelligence [14,15], neural networks [16,17] and Cloud technologies [18–20] enable and will increasingly enable the provision of services to citizens even remotely. Telemedicine [21] and telerehabilitation [22] are and will be increasingly common themes.

The authors of this article [23] carried out an effective survey involving thousands of people and found that individuals with visual snow syndrome had an average age of 29 and no significant difference in sex prevalence. Black and white static was the most frequently reported visual symptom. Other commonly reported visual symptoms included floaters [24,25], afterimages [26], and photophobia [27]. The disorder typically manifests in early life, with approximately 40% of patients experiencing symptoms for as long as they can remember [23]. In this study, concentrated in a sample of 1015 people in the United Kingdom, it was found that approximately 2 percent of people are affected by Visual Snow [28].

3 The Proposed Solution

The JavaScript programming language is extremely versatile and allows the programmer to write code that can then be executed on users' devices regardless of

the operating system they use. JavaScript is in fact executed within the browser, and it is therefore the browser that is responsible for interpreting and executing the code. For this reason, it was decided to develop the code that deals with rendering directly client-side and in a high-level language such as JavaScript. It is important to note that, between the various browsers, there may be small but important differences in the interpretation of JavaScript code and in the performance that can be achieved. As of March 2023, the most popular browsers are Chrome with 64.8% market share, followed by Safari with 19.5%, Edge with 4.63%, Firefox with 2.93% and then other smaller browsers such as Samsung Internet and Opera[3]. In developing the code that will be presented in this section, we have therefore focused mainly on compatibility with the Chrome browser and Safari.

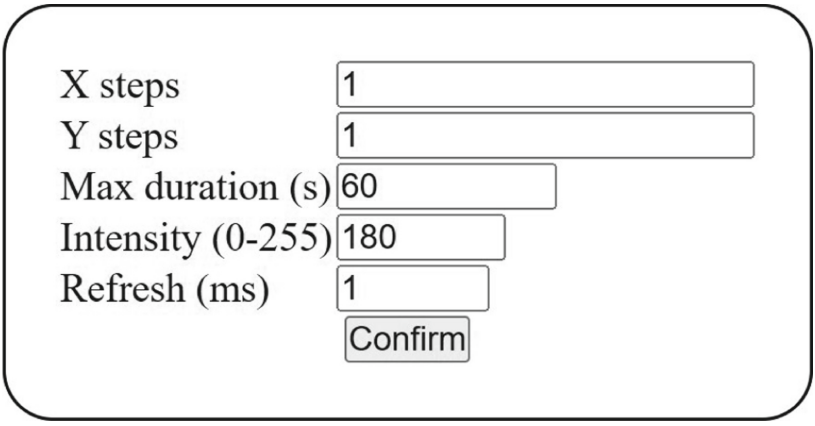


Fig. 1. User interface for the developers

Figure 1 shows the graphic interface used by the developers to calibrate some of the parameters used to generate the video noise that is represented on the screen. The first two parameters are called "X steps" and "Y steps". These identify the density of points to be handled by the algorithm. If for example "X steps" is set equal to 1, then the algorithm will scan the matrix of pixels in steps of 1 pixel at a time in a horizontal direction. If a value of 10 is set, then the algorithm will then process every 10th pixel. The same mechanism is defined for the variable 'Y steps'. This makes it possible to test different exercises with different densities of video noise on the screen, e.g. one might want to create a stream with extremely dense noise on the left eye and a stream with little video noise on the right eye.

The 'Max durations' parameter allows the maximum duration of an exercise to be expressed in seconds. This will allow experts to define exercises with a predetermined time, for example 60 s or several minutes, and allows us to test how the software behaves when performing sequential exercises with a predetermined duration.

[3] https://www.similarweb.com/browsers/.

The "Intensity" parameter is used to calibrate the colour level that the pixels must take on: In the current project, noise is generated by the constantly changing colouration of the pixels. The pixels take on two types of colour: black or coloured. In the case where the pixel under consideration is to be coloured black then its RGB component will be equal to (0,0,0). In the case where the pixel is to be coloured its RGB component will be equal to (X,X,X) with X equal to *Intensity*.

The 'Refresh' parameter indicates the refresh time of the noise shown on the screen. This allows you to define how quickly the screen shown on the display should change. A value of 1ms means that every millisecond the screen containing the noise will be refreshed, generating a new one randomly.

The proposed algorithm for generating video noise uses a canvas that expands across the width and height of the page to occupy 100% of its space. The canvas is an HTML object compatible with all browsers and is predefined at the implementation level[4]. Each point on the canvas will represent one pixel of the monitor. Through a double for loop, the list of pixels is scrolled. For each pixel, the Math.random function is called, which generates a random flaot number between 0 and 1. If the extracted number is greater than 0.5 then the pixel will be coloured with the value of *Intensity* requested by the programmer, otherwise it will be coloured black. Iterating this block of code in accordance with the set refresh rate results in a random, constant generation of video noise.

```
function setColor(i,color){ //0=black; 1=colored
    if(color==0) {
        buffer32[i] = 0; // R
        buffer32[i+1] = 0; // G
        buffer32[i+2] = 0; // B
    }else{
        buffer32[i]=intensity; // R
        buffer32[i+1]=intensity; // G
        buffer32[i+2]=intensity; // B
    }
}
for(let x=0;x<c.width;x+=xSteps){
    for(let y=0;y<c.height;y+=ySteps){
        let i = 4 * (x + y * c.width);
        if(Math.random()<0.5){
            setColor(i,1);
        }
        else{
            setColor(i,0);
        }
    }
}
```

Listing 1.1. Sample of the algorithm

[4] https://developer.mozilla.org/en-US/docs/Web/API/Canvas_API.

Figure 2 shows an example of video noise simulated by the proposed algorithm with *Intensity* set to 188. Figure 3 shows an example of video noise simulated by the proposed algorithm with *Intensity* set to 255. An example of video noise simulated by the proposed algorithm with *Intensity* set to 255, *Xsteps* set to 3, and *Ysteps* set to 2 is shown in Fig. 4.

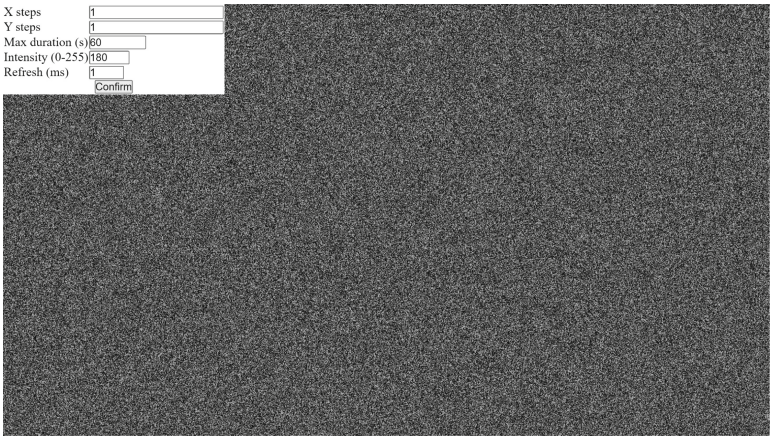


Fig. 2. Noise sample, intensity 188, Xsteps 1, Ysteps 1

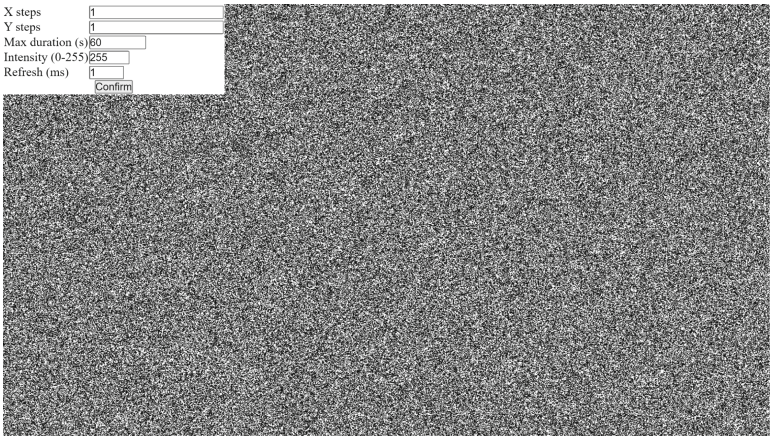


Fig. 3. Noise sample, intensity 255, Xsteps 1, Ysteps 1

The comparative Table 1 shows a comparison between the two approaches, the one involving the presentation of noise via video clips and the one generating



Fig. 4. Noise sample, intensity 255, Xsteps 2, Ysteps 3

Table 1. Comparative table between the two approaches

Comparison	Video Streaming	Noise locally generated
Data downloaded	2 GB	1 MB
CPU usage	12%	16%
GPU usage	36%	12%

it client-side. The table shows the difference in terms of data download and the difference in terms of CPU and GPU usage. The data was calculated with a Workstation with an Intel CPU i7-5820K@3.2 GHz, 64 GB of ram and an NVIDIA 2700 GPU. As can be seen, much less data is downloaded if a script is used to generate the noise. In addition, local computation increases CPU utilisation but reduces the use of the GPU, which is generally well utilised when displaying films. In order to make the application even more versatile and to be able to run on machines with little computational power, a future development will be to increase the use of the GPU and reduce that of the CPU, by moving the calculations related to editing and processing the colour of pixels to the GPU.

4 Conclusions and Future Work

This work aimed to realise an improvement to be submitted to the Visual Snow Initiative. The aim is to improve the platform with which videos are delivered of the exercises that people with Visual Snow use to try to improve their health condition. What has been realised is a JavaScript algorithm that can be effectively modelled and adapted for all the exercises currently delivered by the platform and is made available to users on the GitHub platform in such a way that any-

one can access this code freely and for free[5]. The use of JavaScript has made it possible to reduce the download required for users to perform the exercise. Each exercise currently on the platform occupies 1.5 to 2 GB of data space. This makes it difficult for people who have a slow Internet connection or are in areas with poor network coverage to access the media files with which to perform the daily exercise. On the other hand, generating the exercise on the client side by downloading a small JavaScript file of just a few KB, which encodes the exercise to be performed, makes it possible to expand the audience of people who can use and perform these exercises even in those areas where network coverage is slow or even partially absent. In addition, the ease with which the code can be manipulated allows new exercises to be generated by the experts involved in devising them, speeding up and hopefully improving the quality of scientific research for the benefit of people and their physical and mental health. In the future we will try to expand this work in two ways: First of all, we plan to expand what we have created for the use of virtual reality visors so that these exercises can be carried out in an immersive environment that thus enables greater effectiveness in treatment, and to do this we will use the environment provided by the Unity software. The second way is to extend the code realised in this article to interface only with web platforms in relation to the needs that will be described by the experts of the Visual Snow Initiatives.

Acronyms

The following acronyms are used in this manuscript:

API	Application Programming Interface
AR	Augmented Reality
JS	JavaScript
MB	MegaByte
KB	KiloByte
VR	Virtual Reality
VSI	Visual Snow Iniziative
VSS	Visual Snow Syndrome

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