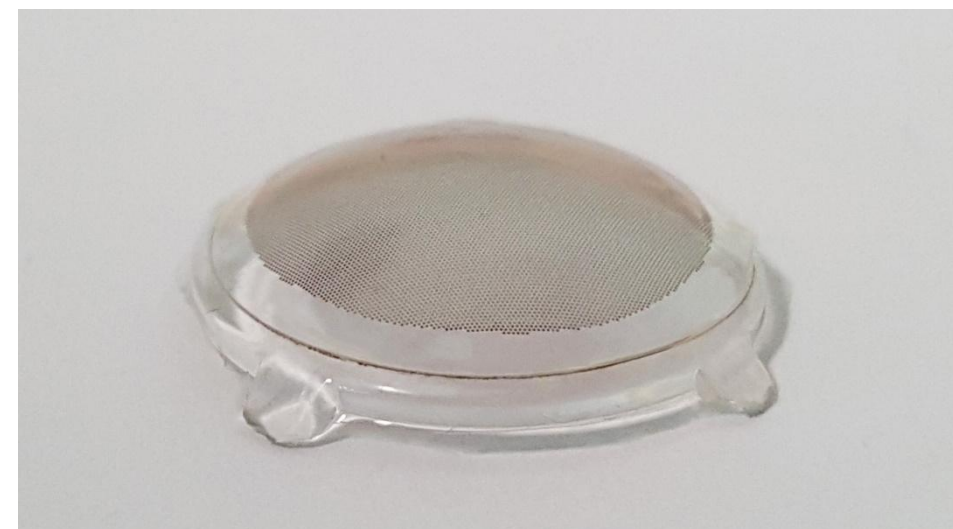
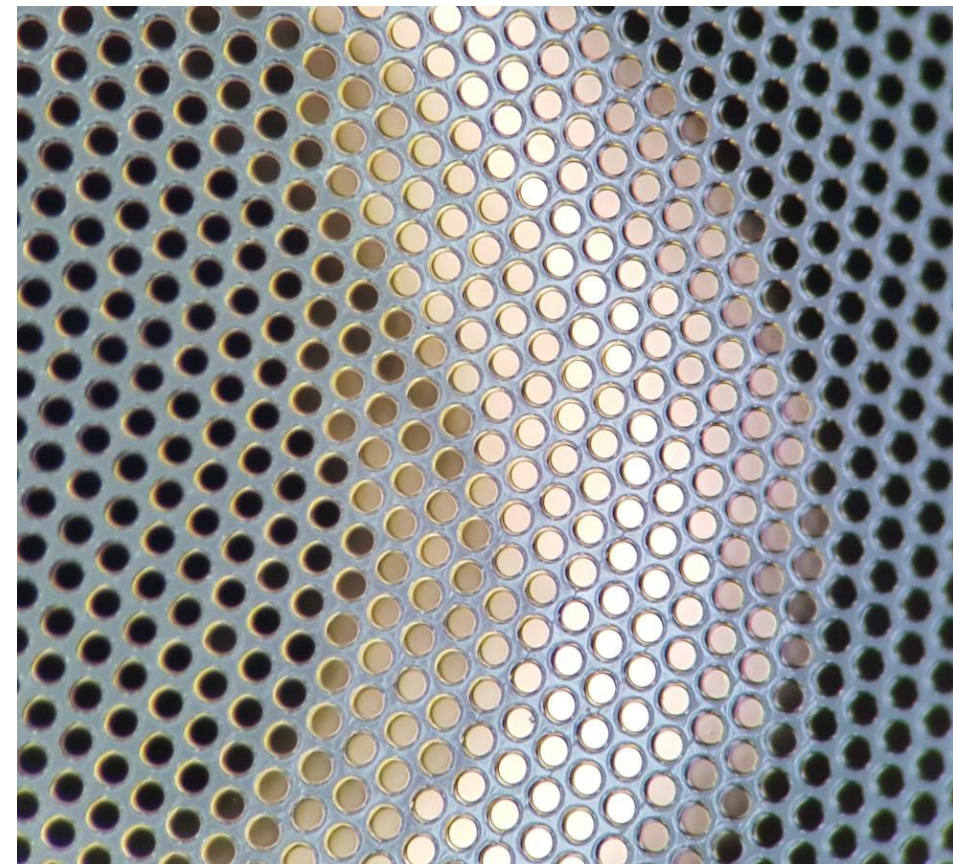
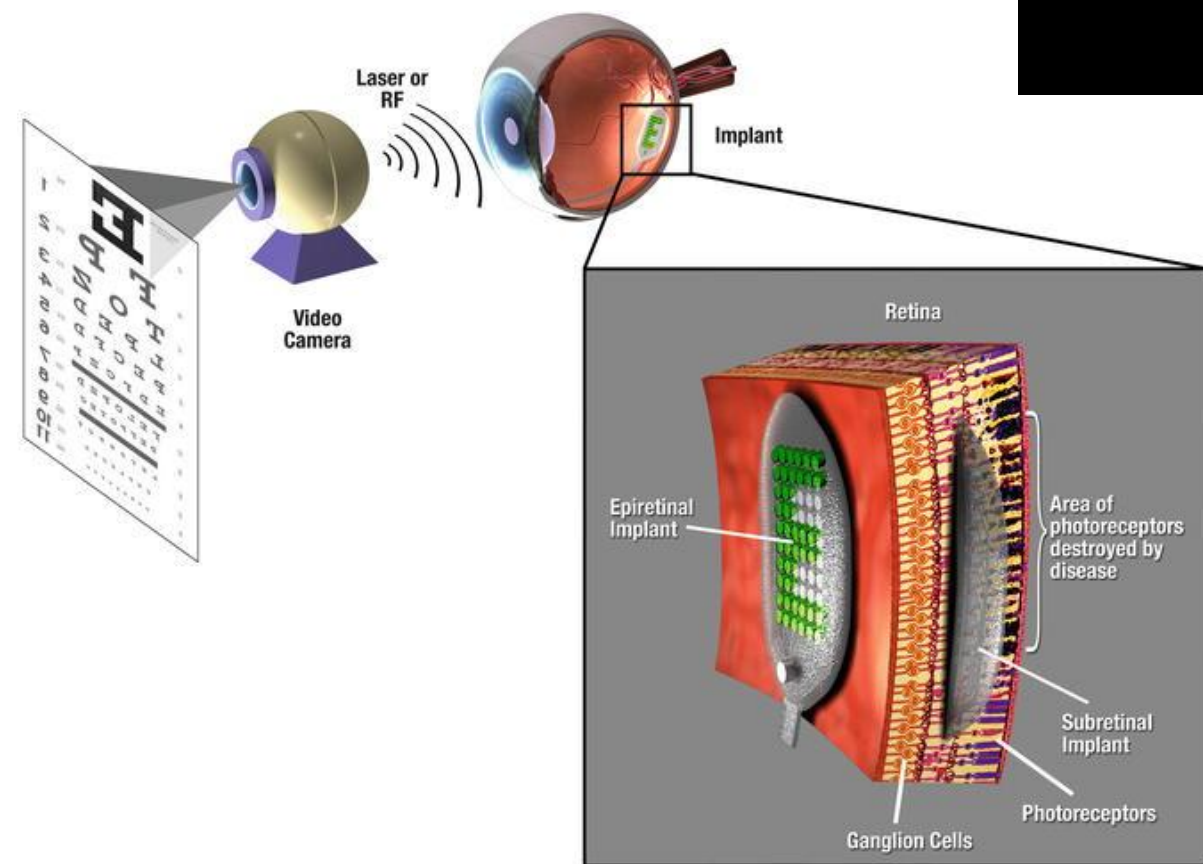
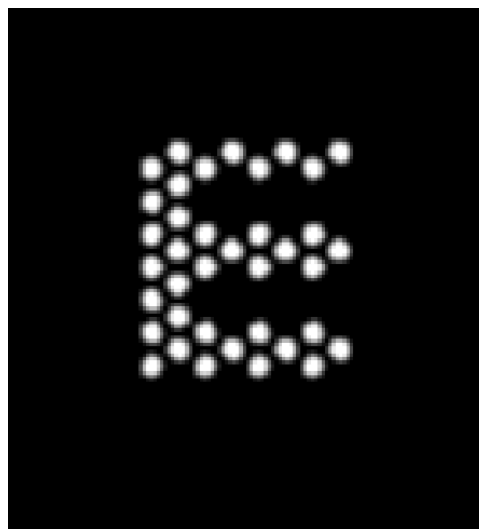


Polyretina



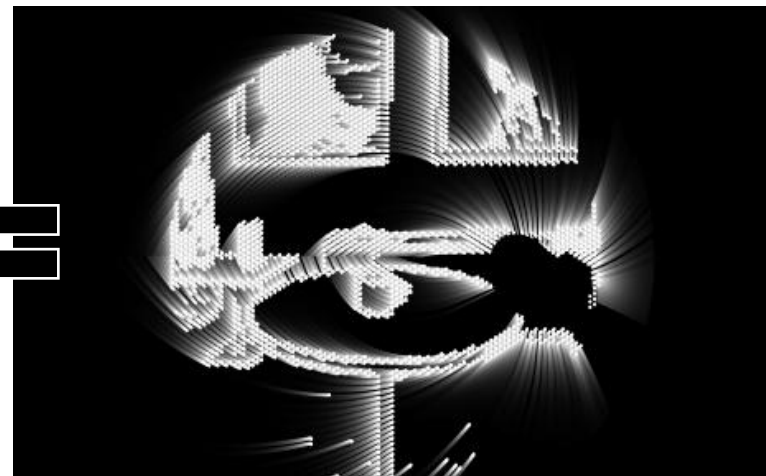
Polyretina VR



+



=



Limitations

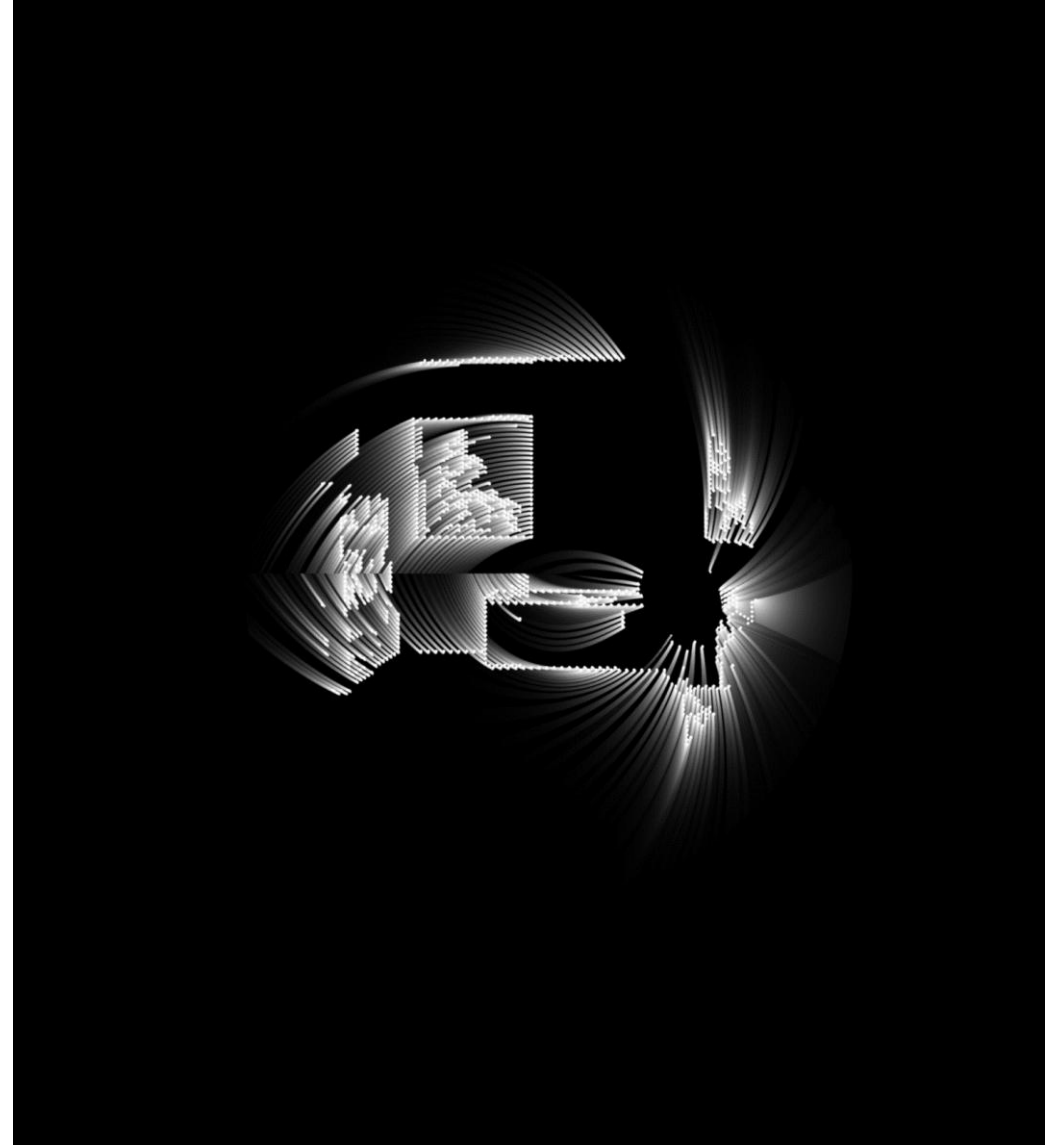


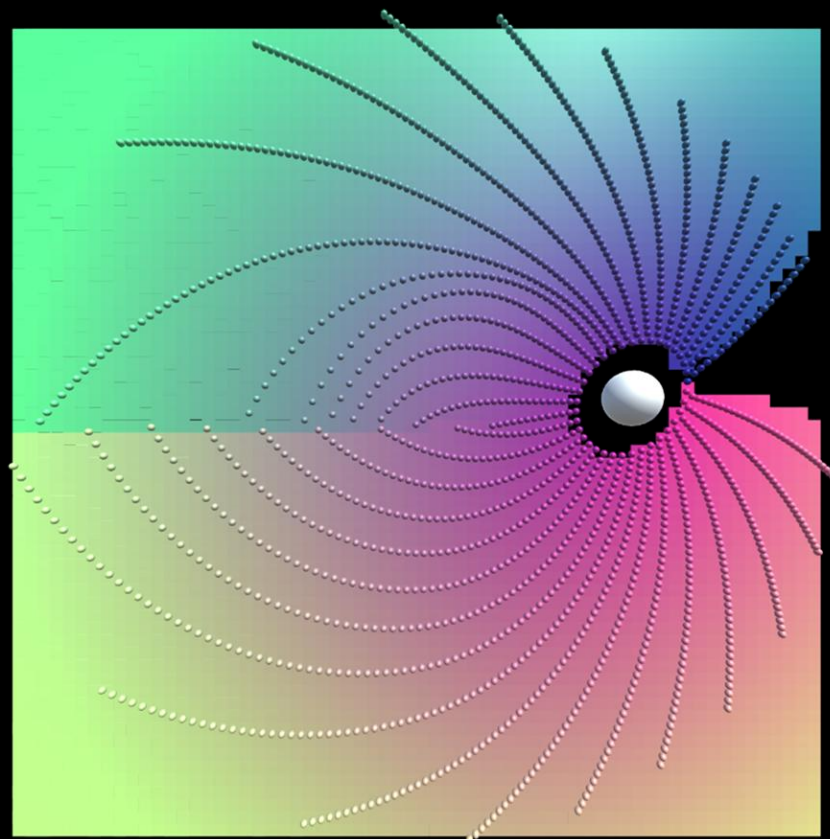
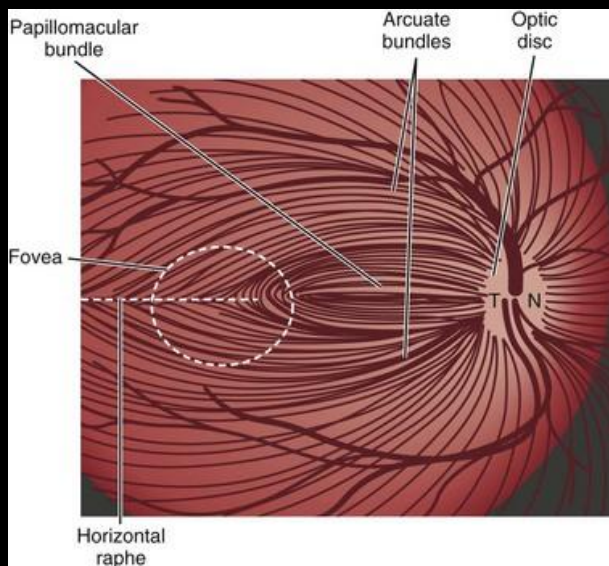
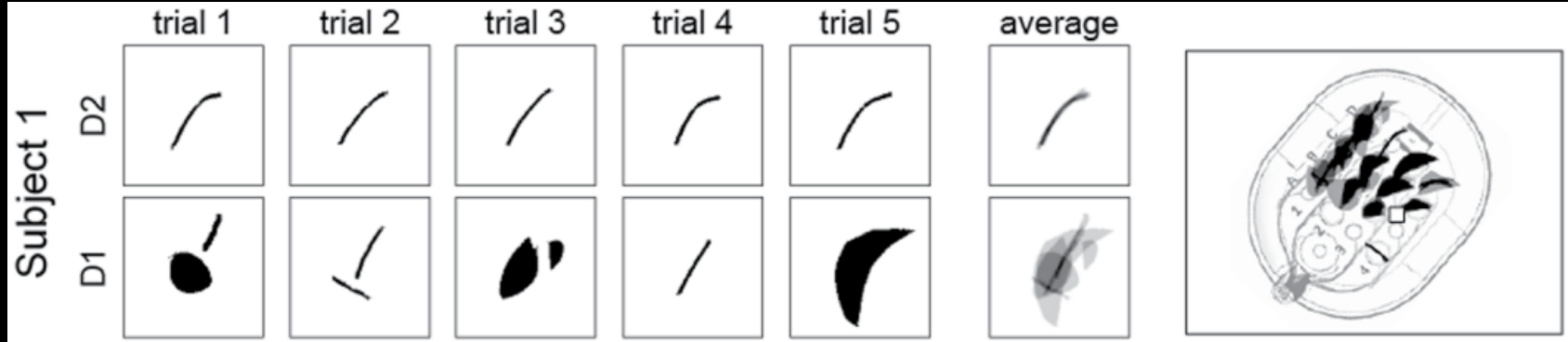
Limitations

- Limited colour space: Black and white.
- Low resolution: $\sim 10,000$ pixels.
- Small field of view: 45 degrees.
- Slow refresh rate: 5Hz.

Distortions

- Axon fibres.
- Desensitisation.





RGB A where:
 R = Φ_0 , G = ρ , B = B, A = C

$$\phi(\phi_0, r) = \phi_0 + b(\phi_0) \cdot (r - r_0)^{c(\phi_0)}$$

$$RMS = \sqrt{\frac{1}{n} \sum_{i=1}^n (\phi_i - \hat{\phi}_i)^2}$$

$$c = 1.9 + 1.4 \tanh\{-(\phi_0 - 121)/14\}$$

$$\ln b = \beta_s + 3.9 \tanh\{-(\phi_0 - 121)/14\}$$

$$x' = x - 15$$

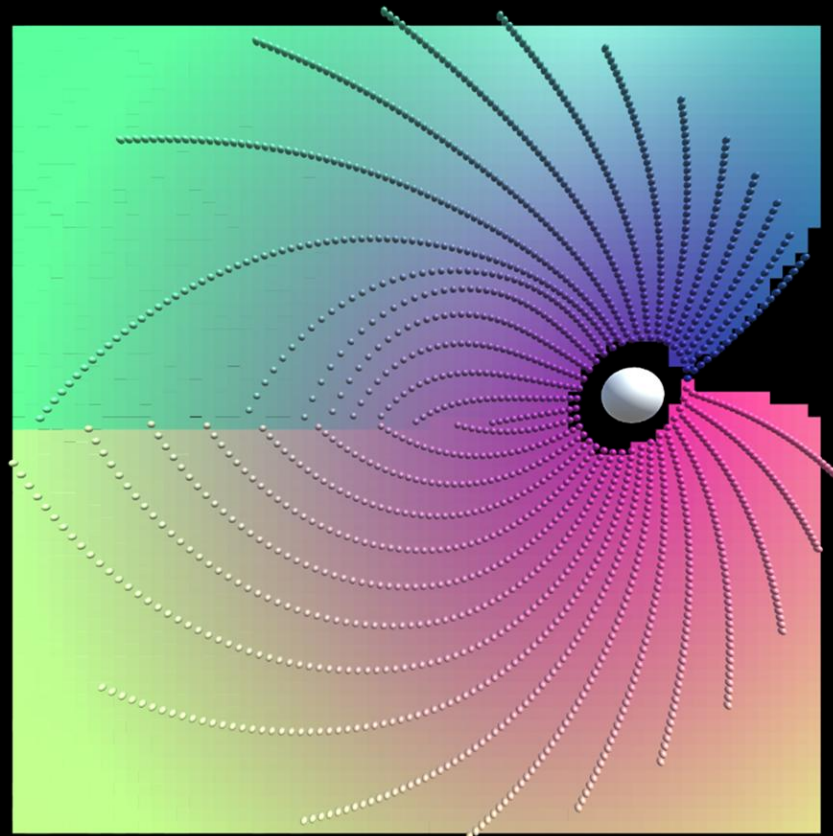
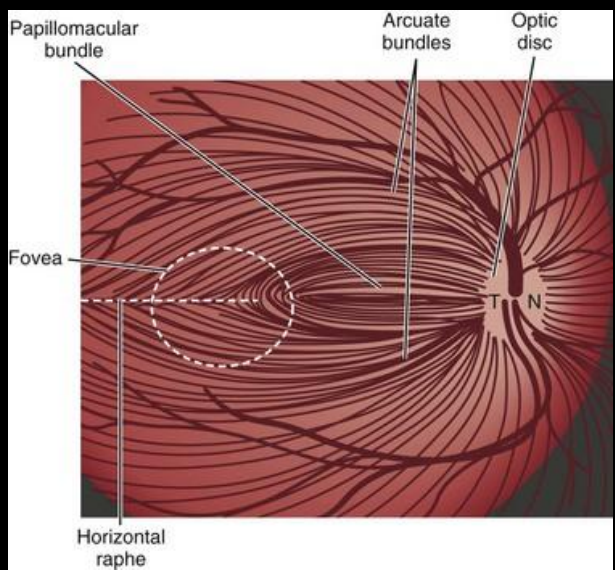
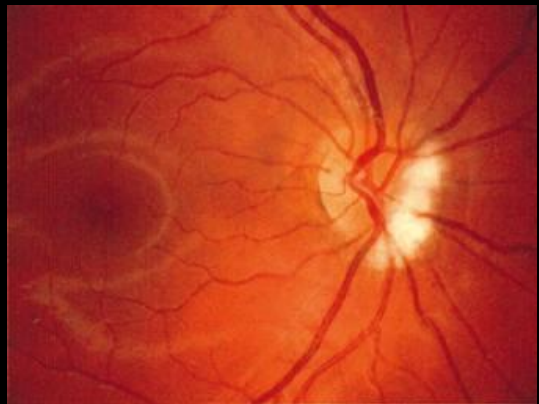
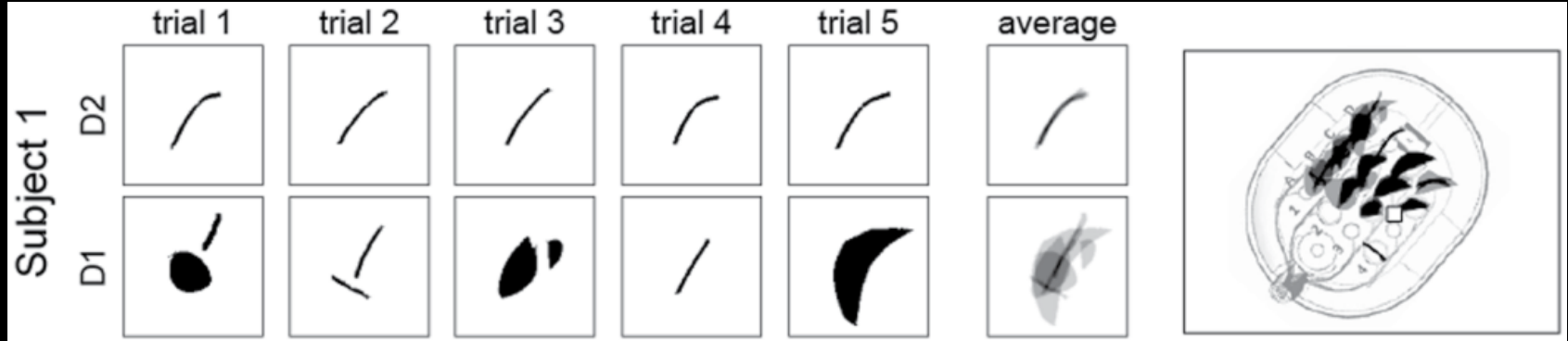
$$y' = y - 2(x/15)^2 \quad \text{for } x > 0$$

$$y' = y \quad \text{else}$$

Second, transformation to polar coordinates (r, ϕ) :

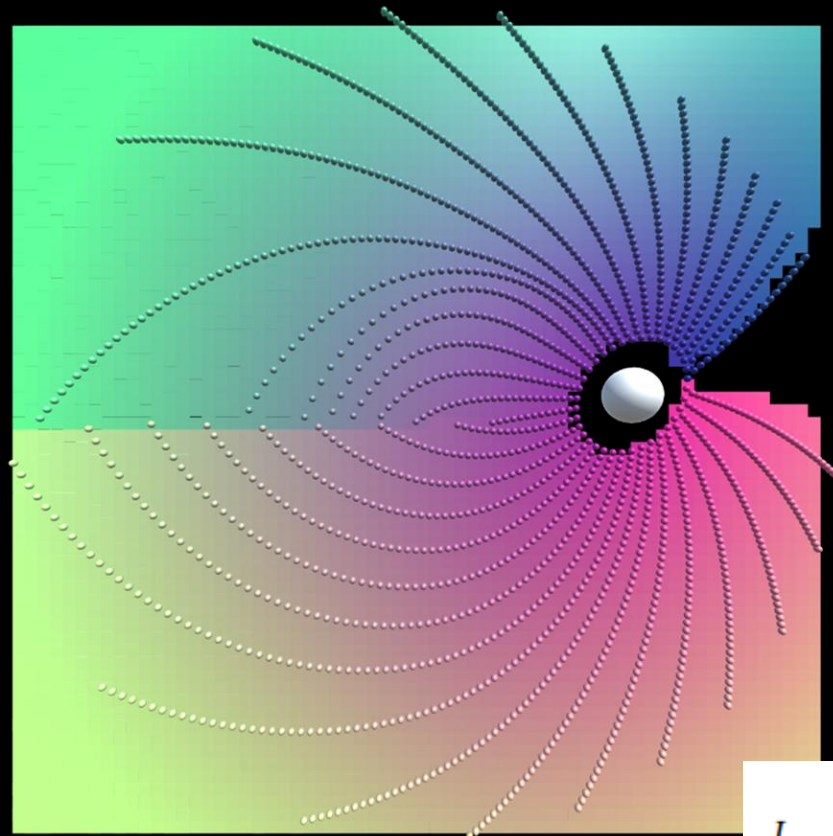
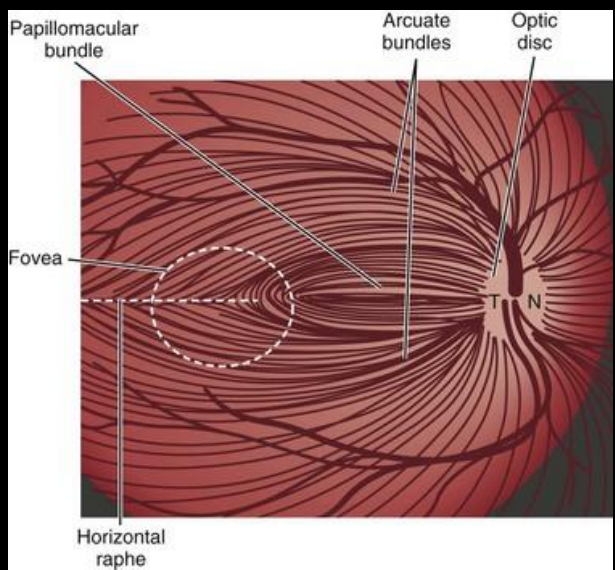
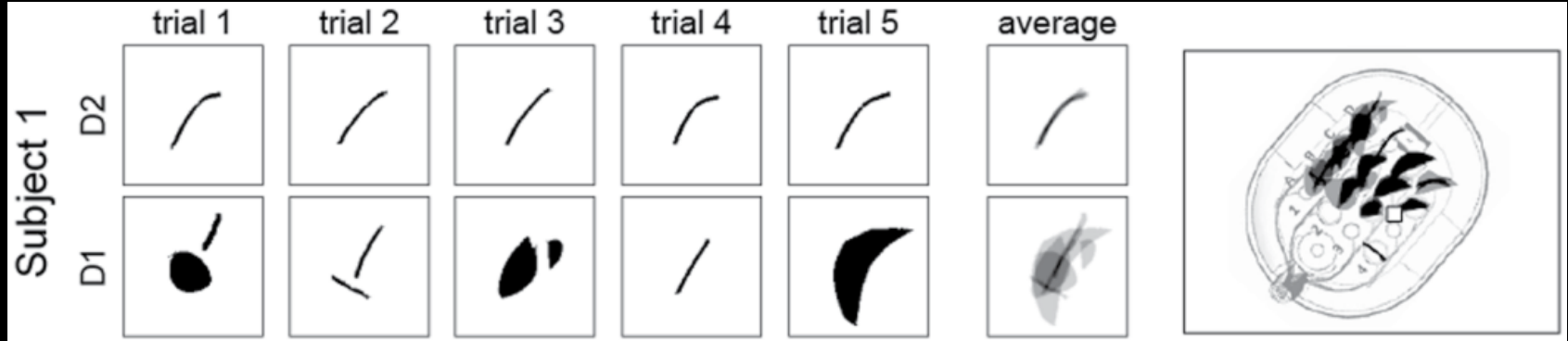
$$r = \sqrt{(x')^2 + (y')^2}$$

$$\phi = \arctan(y'/x')$$



RGB A where:
 $R = \Phi_0$, $G = \rho$, $B = B$, $A = C$

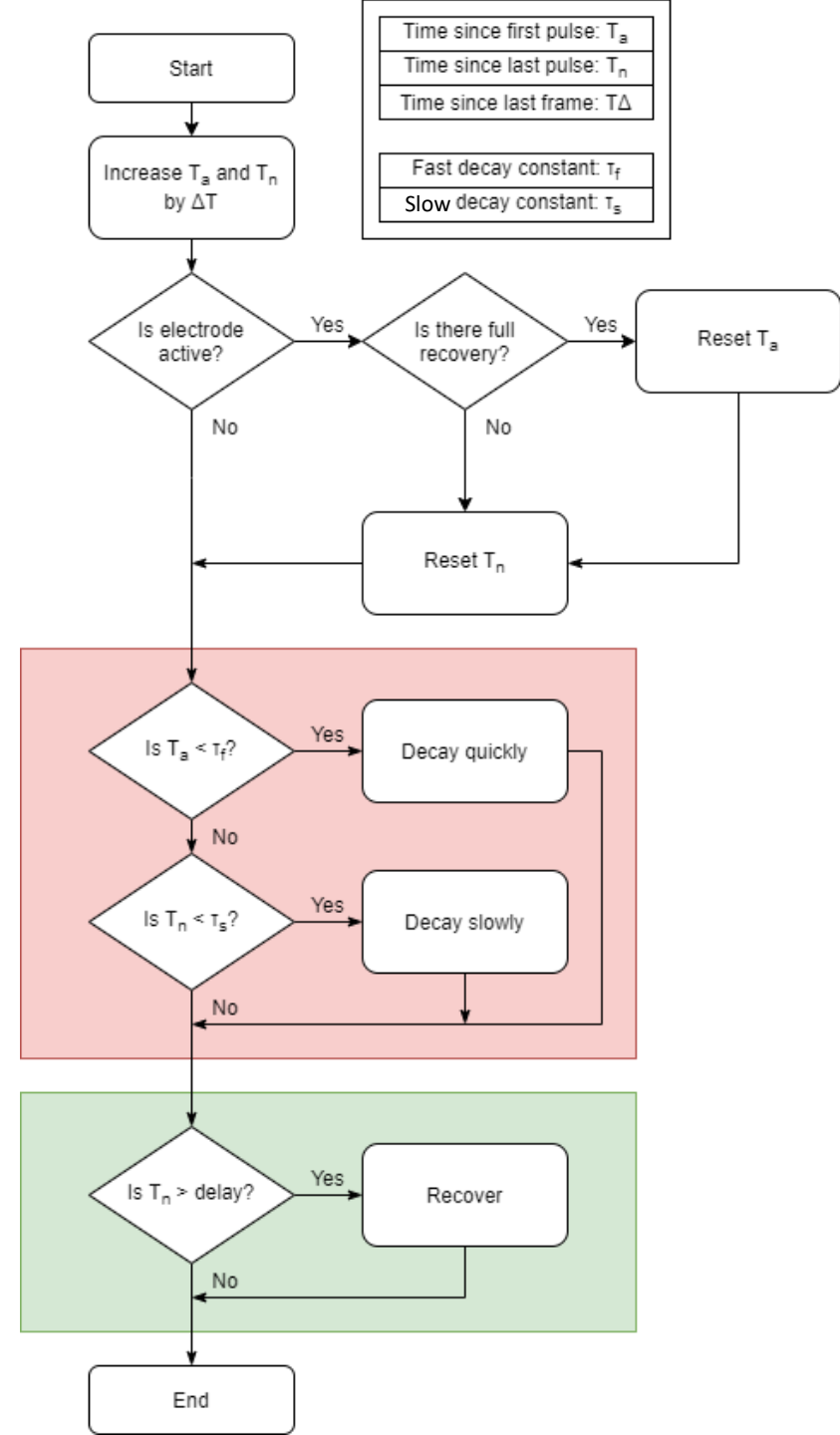
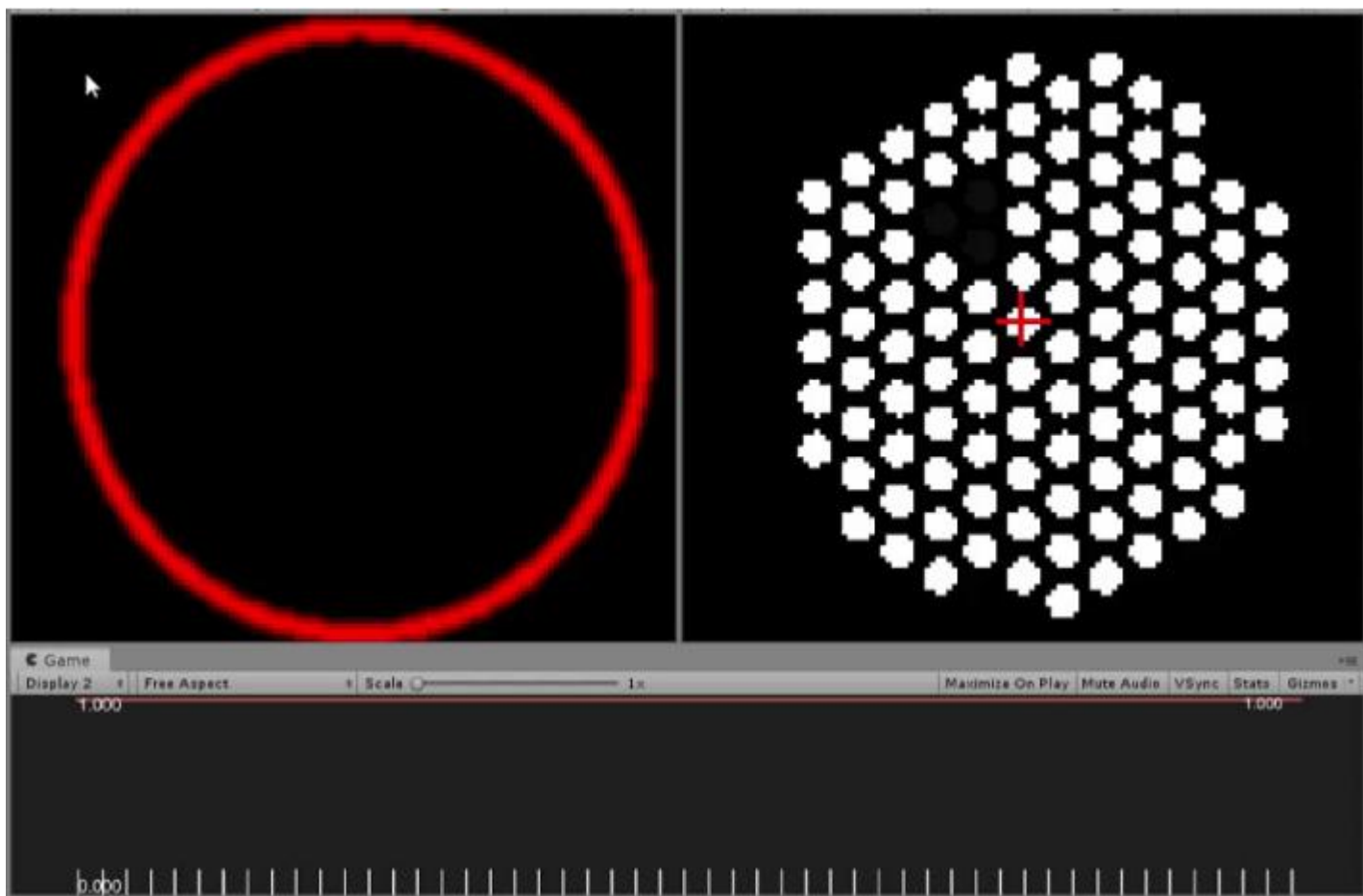


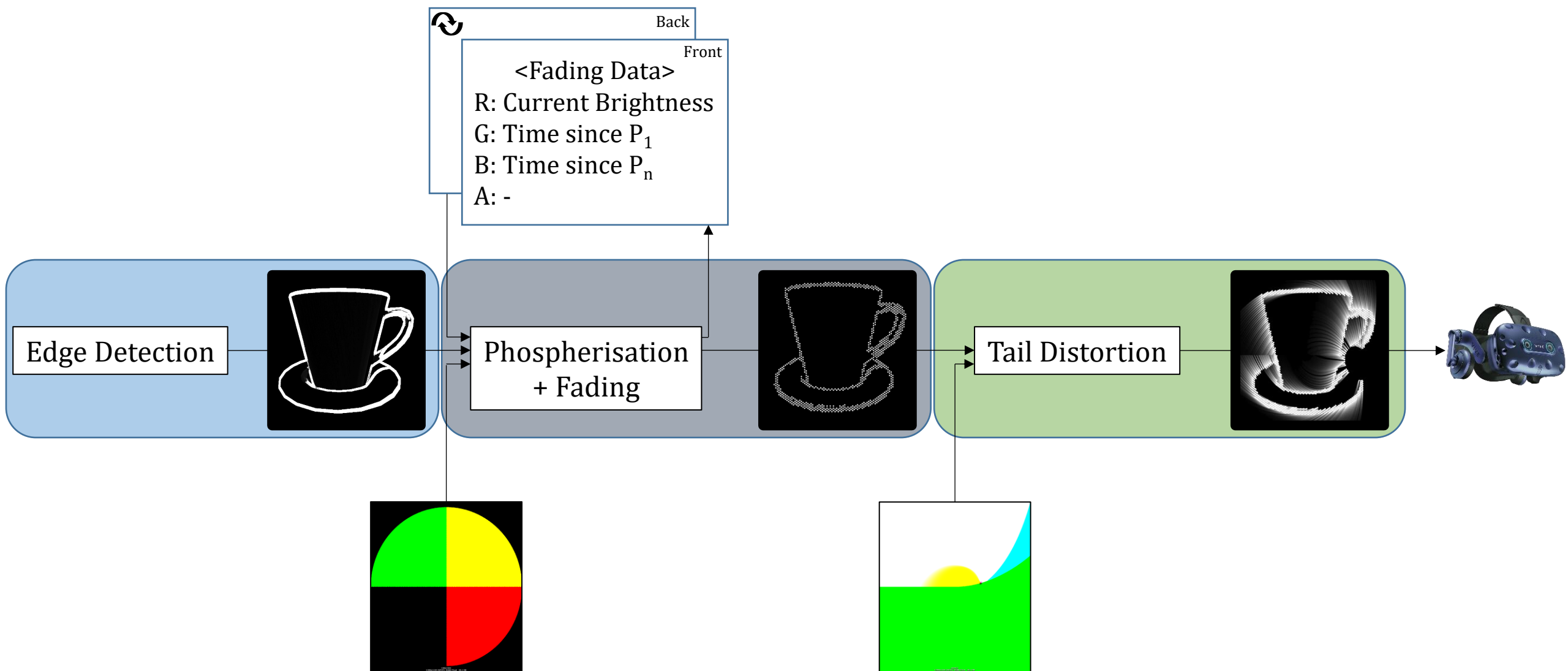


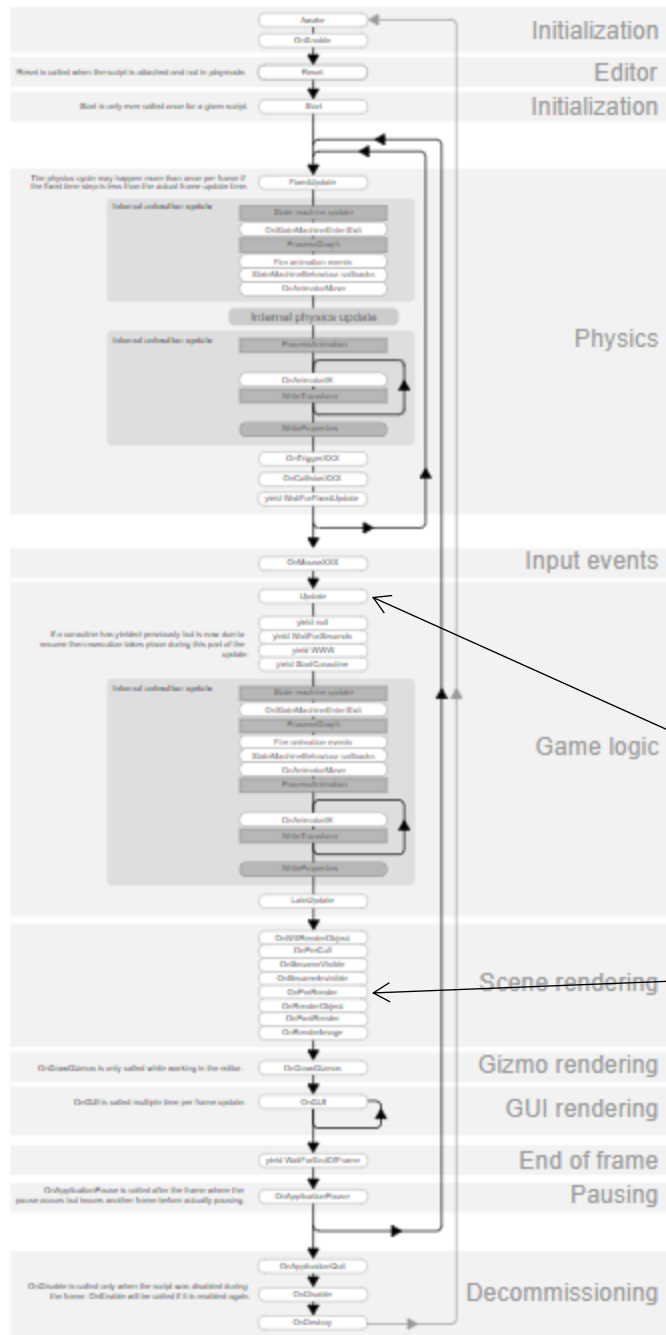
RGB A where:
R = Phi0, G = Rho, B = B, A = C



$$I_{\text{axon}}(x, y; \rho, \lambda) = I_{\text{score}}(x, y; \rho) \exp \left(- \frac{(x - x_{\text{soma}})^2 + (y - y_{\text{soma}})^2}{2\lambda^2} \right)$$







Simulation start

Simulation loop (~90Hz)

Update ()

OnRenderImage ()

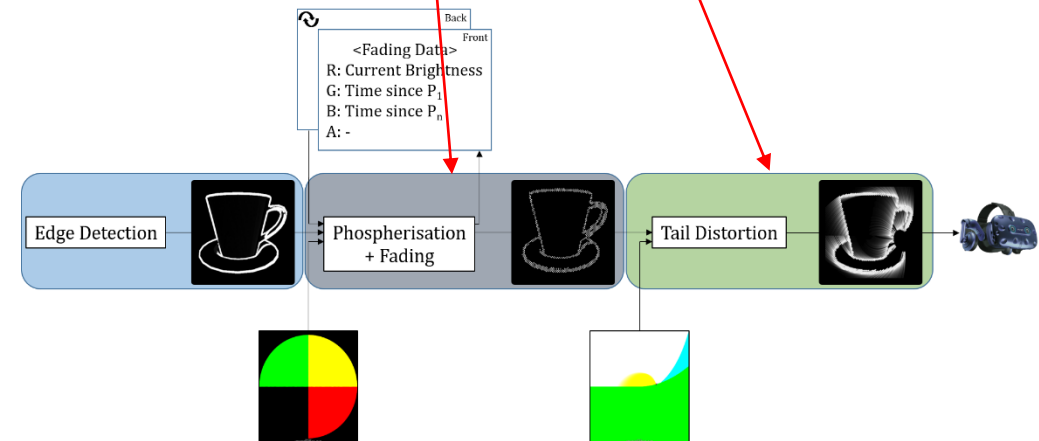
Simulation end

```
public override void OnRenderImage(Texture source, RenderTexture destination)
{
    if (phosMRT == null || tailBlr == null)
    {
        Debug.LogError($"{name} does not have a material.");
        Graphics.Blit(source, destination);
        return;
    }

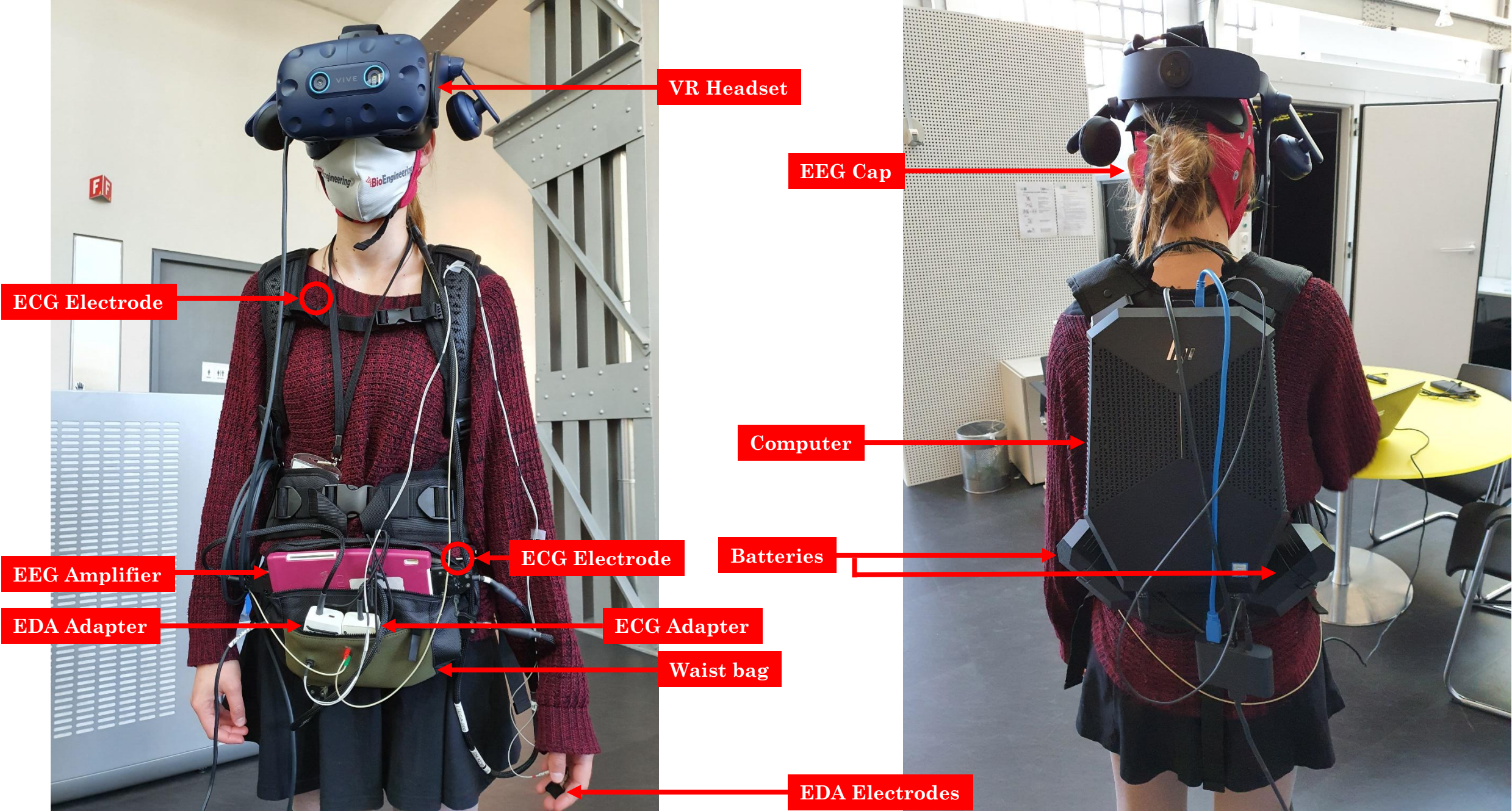
    if (on)
    {
        var tempRT = RenderTexture.GetTemporary(headset.GetWidth(), headset.GetHeight());
        Graphics.SetRenderTarget(new[] { tempRT.colorBuffer, tempRT.depthBuffer });
        Graphics.Blit(source, phosMRT);
        Graphics.Blit(phosMRT, tailBlr);
        RenderTexture.ReleaseTemporary(tempRT);

        fadeRT.Swap();
    }
    else
    {
        Graphics.Blit(source, destination);
    }
}
```

Fragment Shaders



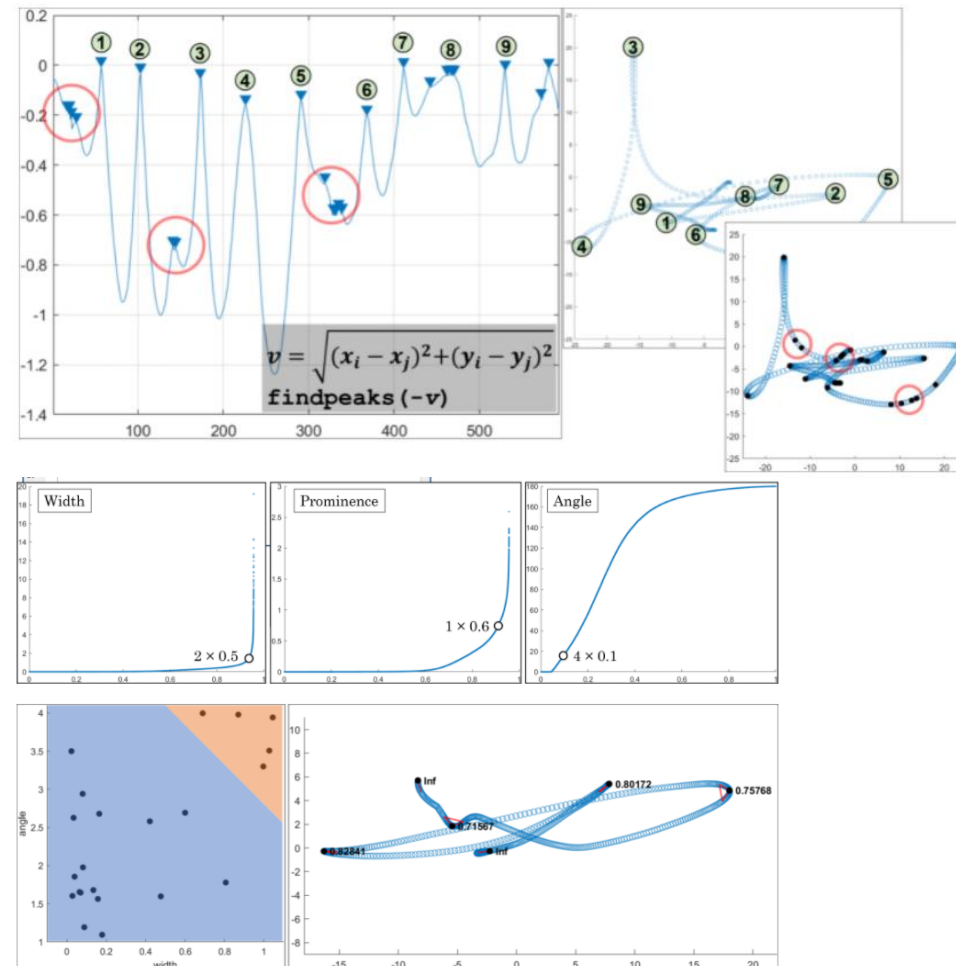
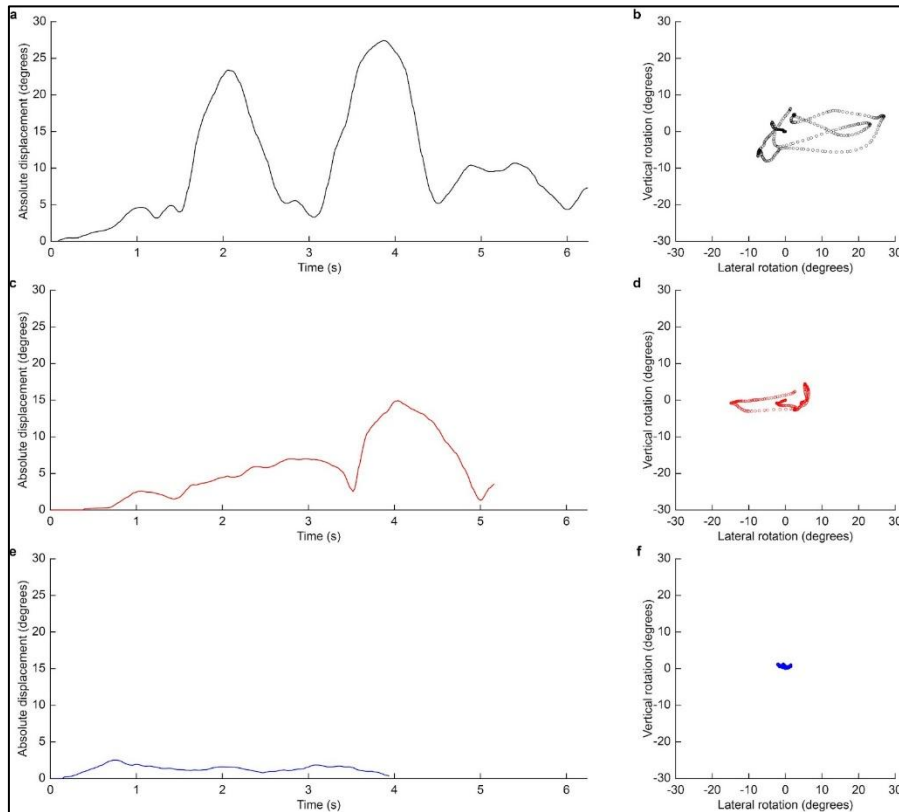
Augmented Reality Study – Complete Setup



Augmented Reality Study – Complete Setup





Head and Eye Movement analysis



Virtual reality validation of naturalistic modulation strategies to counteract fading in retinal stimulation

Jacob Thomas Thorn¹, Naïg Aurelia Ludmilla Chenais¹, Sandrine Hinrichs¹, Marion Chatelain¹ and Diego Ghezzi^{1,2}

Virtual reality simulation of epiretinal stimulation highlights the relevance of the visual angle in prosthetic vision

Jacob Thomas Thorn¹ , Enrico Migliorini¹ and Diego Ghezzi^{1,2} 

A Simulation of Strategies to Counteract Phosphene Fading in Retinal Prostheses

Jacob Thorn, Naïg Chenais, Sandrine Hinrichs and Diego Ghezzi, *Member, IEEE*

A Simulation of Strategies to Counteract Phosphene Fading in Retinal Prostheses

Jacob Thorn¹, Naïg Chenais¹, Sandrine Hinrichs¹ and Diego Ghezzi¹

¹Medtronic Chair in Neuroengineering, Center for Neuroprosthetics and Institute of Bioengineering, École Polytechnique Fédérale de Lausanne, Switzerland



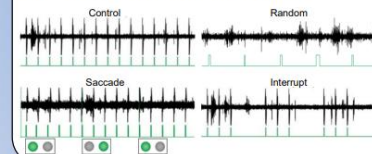
Background



Retinal prostheses offer the capability to restore vision for people suffering from retinal degenerative diseases. However, current technology still has numerous hurdles to overcome such as the fading of percepts that patients can experience due to desensitisation of the stimulus as a result of constant exposure.

Three strategies were found to mitigate desensitisation in a previously conducted ex-vivo experiment. These were the randomisation of the inter-pulse interval (Random), the imitation of natural micro-saccades by having oscillating activation of neighbouring electrodes (Saccade) and the deactivation of all electrodes for 600 ms every 1.2 seconds (Interrupt).

The goal of the current study was to test if these decreases in desensitisation time also translated to increased performance and comfort for users of a simulated visual prosthesis.

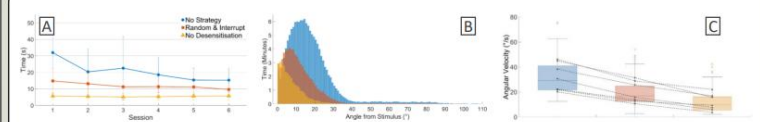


Methods



Participants read words in a simulation of prosthetic vision with combinations of counter-fading strategies enabled. Seven participants completed 300 trials each. Measurements taken were the time to successfully read the words and head rotation.

Results



Initial results revealed that the best strategy for dealing with desensitisation (i.e., the strategy that allowed participants to complete the task the quickest and reduced head movement the most) was a combination of the Random and Interrupt (RI) strategies, with each other strategy or combination of strategies not performing worse than the baseline (where baseline was no strategy enabled).

Figures A and B both show that RI indeed lowered the time taken for accurate identification of the words compared to the baseline and Figures B and C also show a decrease in head movements from participants during the RI condition compared to the baseline. Figures B and C illustrate that the RI condition allowed participants to both be able to keep their head more centralised to the stimulus and facilitated reduced head movement over time as well.

In conclusion, the mitigation of desensitisation found in the ex-vivo study was indeed also found to improve the quality of vision for participants using a simulated visual prosthesis, with the combination of the Random and Interrupt strategies providing the greatest benefit. However, a condition without the fading of the percepts still performed better than RI, indicating that improvements can still be made towards the goal of mitigating desensitisation altogether.

Fondation
Gelbert

[1] N. A. L. Chenais et al., "Naturalistic spatiotemporal modulation of epiretinal stimulation increases the response persistence of retinal ganglion cells," *Journal of Neural Engineering*, 2020.
[2] J. T. Thorn et al., "Virtual reality simulation of epiretinal stimulation highlights the relevance of the visual angle in prosthetic vision," *Journal of Neural Engineering*, 2020.

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