Limited color perception as an another property

Limited color perception in infants refers to the gradual development of an infant's ability to perceive colors, a capability that is not fully developed at birth. Newborns primarily respond to high-contrast patterns and are sensitive mainly to red tones, followed by blue, and then green as their visual systems mature. This limited color perception serves as a protective adaptation, allowing infants to focus on essential visual details, such as caregivers' faces and surrounding environments, without being overwhelmed by the full color spectrum.

Research has shown that infants' color perception develops gradually and in distinct stages. The color perception development process first starts with red-green, and the blue-yellow around 4 to 8 weeks later. By this way, infants become trichromatic by 3 months. Although infants become trichromatic, the ability to detect desaturated colors is still poor, due to the saturation thresholds that do not reach adult levels until late adolescence. [Skelton, A. E., Maule, J., & Franklin, A. (2022). Infant color perception: Insight into perceptual development. Child Development Perspectives, 16, 90–95. https://doi.org/10.1111/cdep.12447].

Implementation

In the Visual Acuity class, we simulate the progressive improvement of infants' visual acuity over time by adjusting the level of Gaussian blur applied to images. The blur level is determined by the infant's age in months. Younger infants have lower visual acuity, represented by a higher blur (higher sigma in Gaussian blur), while older infants see more sharply as their visual acuity improves. This transformation mimics the gradual sharpening of vision infants experience as they grow, with a calculated visual acuity and corresponding blur that decreases as age increases.

The Limited Color Perception class simulates infants' gradual development of color perception. Infants initially perceive colors with limited saturation, starting with higher sensitivity to red, then blue, and finally green tones. To mimic this, we applied an RGBAndContrastTransform() to limit the maximum value of each color channel based on the infant's age. Each color channel has incremental maximum values that increase with age, simulating the natural development of color sensitivity. Additionally, a contrast adjustment further enhances the simulation, providing a more accurate representation of how infants perceive colors at different stages of early development.

Performance Evaluations of Data Loaders

In order to find out how effective these transformations have been on our dataset, we performed some performance evaluations in terms of average load time and standard deviation on three different setups, namely: *Limited Color Perception*, *Visual Acuity*, and a baseline setup with no transformation. Each of these has been further tested in loading up 100 images for 100 iterations to keep the metrics consistent and reliable.

Results show that *Limited Color Perception* and *Visual Acuity*, with average times of 0.0357 and 0.0317 seconds, respectively, are about 2.2 to 2.5 times slower than the baseline loader without transformations, with it's average of 0.0144 seconds. These findings bring into focus the computational trade-offs involved in applying transformations during data loading.

***The tests were run on a MacBook Pro with an M3 processor and 16GB of RAM.*

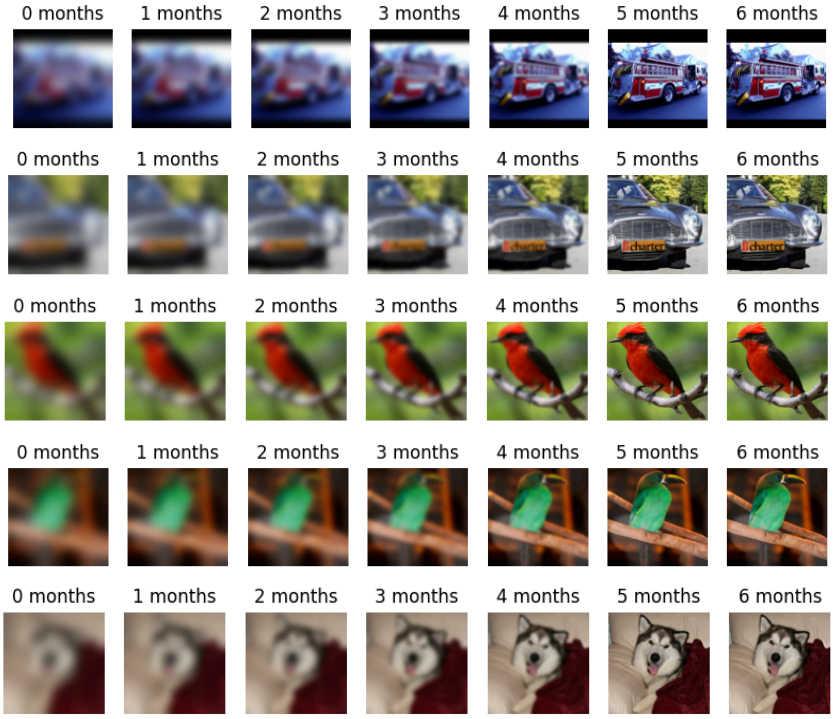

Figure 1.1. *Progression of simulated infant visual acuity from newborn to 5 months, illustrating the gradual reduction in blurring as visual sharpness develops with age.*

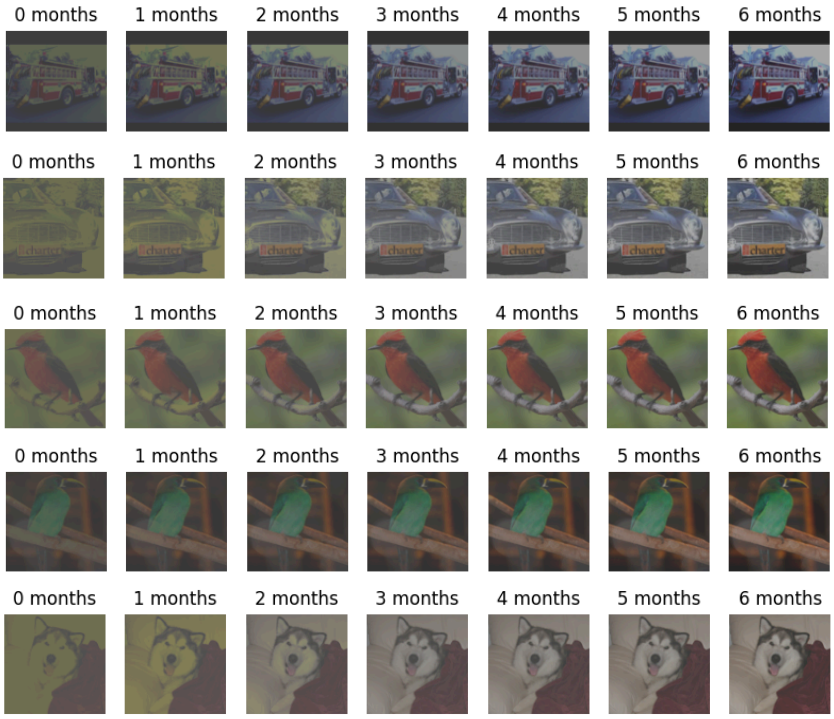

Figure 1.2. *Progression of simulated infant color perception from 0 to 6 months, illustrating the gradual enhancement in color sensitivity as perception of red, blue, and green tones develops with age.*

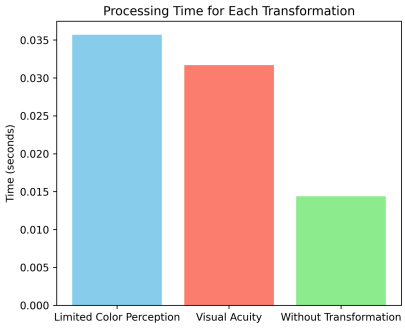

Figure 1.3. *Average processing time for each transformation in 100 iterations*