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HORUS EYE: See the Invisible Bird and Snake Vision for Augmented Reality Information Visualization

Neven A. M. ElSayed* Ross T. Smith† Bruce H. Thomas‡

Wearable Computer Lab
University of South Australia

Figure 1: (a) Horus Eye visualization, Bird vision for isolating background/foreground object of interest and a snake vision for gradient highlighting, (b) Object bars visualization using transparency, (c) The keystone, a context-based visual cues.

ABSTRACT

This paper presents a novel technique, called Horus Eye, for augmented reality information visualization. "Horus", the famous deity in ancient Egyptian mythology, inspires this visualization technique, which is designed to simulate bird and snake vision to highlight data of interest. The contribution of this approach is the merging of information with the real scene, leveraging the real world context to interpret the data. Our technique is a context-based interactive visualization, controlled by users' queries. This paper presents a work in progress with use cases and two adaptations of Horus Eye.

Keywords: Horus Eye, Augmented Reality, Visualization, Information Visualization, Blended Information, Scene Manipulation, Diminished Reality.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented and virtual realities; I.3.6 [Computing Methodologies]: Computer Graphics—Methodology and TechniquesInteraction Techniques.

1 INTRODUCTION

Birds have a unique visual ability to perform fast maneuvers while avoiding obstacles. A bird's vision [11] has ultraviolet sensitivity, allowing them to see the ultraviolet light reflected off objects. This sensitivity fosters the perception of additional light patterns not visible to humans. This visual ability also allows birds to detect the environmental features faster and from further distances. In our adaptation of this method for AR, we stretch the visible light's wavelength range. The results form a blue-tinged background, and they provide a high contrast between the glowing emission and the background color.

*e-mail: neven.elsayed@mymail.unisa.edu.au
†e-mail: ross.smith@unisa.edu.au
‡e-mail: bruce.thomas@unisa.edu.au

Upon investigating this phenomenon, we found that ancient Egyptians also recognized the advanced abilities of bird sight. Horus, the god of hunting, was acclaimed for his extraordinary visual acuity. He was depicted as a man with a falcon head. His visual power was symbolized in the *"Wedjat"*, later called "The Eye of Horus", with a cobra leading the eye symbol and followed by a falcon with open wings (see Figure 2a). By encoding the *"Wedjat"* from the perspective of the light spectrum, the cobra represents infrared sensitivity, and the falcon represents ultraviolet sensitivity. The Eye of Horus divides the senses into fractional parts [9], revealing a well-known formula, discovered in Rhind Mathematical Papyrus. The Horus fraction assigns a unit fraction to each part of Horus's eye, with a unit number and denominators six powers of two (see Figure 2b). Each fraction represents a sense's ratio. The total value of these senses is 63/64, with the missing 1/64 being a mystery sense only available to Horus. This formula assigns a vision's filter on the *"Wedjat"* that is distributed in the eye's zones. Inspired by this ancient knowledge, we saw the potential for simulating Horus' powerful vision by altering the weightings and ratios of the color spectrum of a user's view to assist with information visualization.

We are actively investigating visualization techniques for augmented reality (AR) information visualization [4, 6, 5] to address existing limitations. One challenge facing AR visualization is a po-

(a) (b)

Figure 2: The Eye of Horus. (a) An illustration of the "Wedjat", later called "The Eye of Horus" (b) Horus eye's fraction breakdown.

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(a) (b)

Figure 3: Scene manipulation illustration (a) A real scene of a bookshelf (b) Horus eye simulated vision for the bookshelf scene.

tentially cluttered background and limited display area. Figure 3a shows a cluttered scene of a bookshelf, with different book sizes, shapes, and colors. Some of these objects have an insufficient surface to accommodate overlaid visual cues (arrows, text, or shapes), making it difficult to highlight or point to individual titles with existing AR methods such as border highlighting or arrows. Figure 3b shows a simulation of the bird vision method where color coded representations are employed to blend the book spines with augmented meaning through opacity. The brightness of the color represents the relevance to the user's query, and colors are used for clustering. The color coding improves a user's ability to detect pertinent information, regardless of the physical object's size, shape, or pose. The technique compresses the colors of the scene's background to the blue spectrum that provides a high contrast to the highlighting colors.

Recently, scene manipulation approaches were introduced for AR visualization [14], manipulating the real scene for data embedding, such as highlighting scene features [12] or guiding the assembly of parts [13]. These techniques show a potential solution for blended spaces' visualization [1] by reducing the visual clutter resulting from overlaying data on the real scene. These approaches have not been used to date for AR information visualization. Opacity and contrast are also well-known approaches that are being used for AR visualization. Livingston et al. [19] have used opacity and intensity techniques to reduce the visual clutter resulting from the overlapped layers.

This paper presents a novel interactive visualization approach for AR information visualization (see Figure 1), with five main components:

- A simulated Bird Vision technique, for the background manipulation of the real scene,
- A simulated Snake Vision visualization for data representation,
- The Horus lens, a contextual-based brightness filter,
- Objects bars, a depth-based interactive bar chart visualization, and
- The Keystone, a contextual-based visual cue.

Following the introduction, this paper discusses the related work in AR visualization. We then describe the five components of our approach. This description is followed by a discussion on the future work. The paper finishes with a set of concluding remarks.

2 Related Work

Kalkofen et al. [14] have classified the AR visualization techniques into three principal approaches: data integration, scene manipulation, and context-driven visualization. Data integration techniques generate and calculate perception cues, by registering the virtual data to the real scene. Scene manipulation techniques manipulate the real scene, enabling possibilities such as relocating real-world objects. Context-driven visualization techniques alter the visualization appearance, taking into account the contextual information provided by the real scene.

The major challenges facing AR visualization is the limited display space and the dynamic cluttering of the background. Investigations into AR visualization pursue two main paths: 1) reduce the amount of the presented data and 2) modify the layout of data. With the increasingly large amount of data and the increased desire of employing AR in real-world applications, masking or reducing the amount of data cannot always be satisfactorily achieved for AR information visualization in searching tasks [15] and browsing [16].

Livingston et al. [19] utilize opacity and intensity to reduce the visual representation of cluttering, which results from the overlapped layers. Their technique uses a combination of wired and filled drawings assigned with different opacity and intensity values based on the visualization's depth. The results showed that using opacity and intensity have increased the accuracy of differentiating the layers' order, and the users preferred the combination of wire and filled representation.

Interactive 4D overview and detail visualizations [23] are one of the recent approaches, which present AR information visualization to support overview, zoom, and focus and context representation. This method is focussed upon presenting data over time. They provide three visualization levels that vary in the amount of detail and abstraction; they allow the user to peruse the time-oriented information in an understandable manner. They used physical objects, such as buildings, as representation canvases. Veas et al. [22] have proposed a visualization approach for environmental monitoring, with three main parts: data exploration, view management, and collaboration. The approach is to provide two interactive methods: first is multi-view AR and second is a variable perspective view. They used a graphical structure and color-coded techniques, which blend the visualization with the real scene.

Scene manipulation approaches use the real scene's content to represent the data. The prominent advantage of this approach is the ability to retain the contextual relationships in the physical world. Color, illumination, and harmonization are some of the used scene manipulation techniques to enhance the AR view [12, 2, 17]. Diminished reality [18] can be considered as a scene manipulation approach, removing objects from the real scene and keeping the focus on the points of interest.

Information visualization in AR is a challenging approach to provide visual embedded information into the user's field of view and surround the user with information in-situ to their activities [20]. The current investigations proposed some promising approaches, but they cannot be applied to small physical objects, with various size and shapes.

3 Techniques

This section describes our novel visualization technique inspired by the concept of the "Horus Eye". This technique is an interactive information visualization approach. Our proposed technique has five main parts: A *bird vision* simulation for scene background, a simulated *snake vision* for data representation, *Horus lens* for context-based brightness, *object bars* for physical object comparisons, and *keystone* for context-based visual cues. The following sections explain each component in detail. We employed our technique to a shopping context for moderately sized tracked boxes to support reasonably long distance tracking.

3.1 Bird Vision

Many birds have ultraviolet sensitivity, allowing them to see patterns that are invisible to humans [11]. These ultraviolet patterns result from objects' fluorescent emissions, enabling birds to perform faster decisions when flying and hunting.

The Horus Eye bird vision emulates the stretching of the RGB color spectrum to RGB plus ultraviolet, which results in a bluish and high-contrast background. We do not employ special camera technology that is sensitive to wavelengths outside a human's normal vision. We used OpenGL shaders, C#, and Vuforia SDK for natural features tracking in Unity 3D to alter the representation. Each tracked physical object is associated with multiple textures maps that are assigned based on the user's query, by using tapping interaction. We avoided traditional cursor based interactions techniques [21], as they were not a natural extension to the AR visualisations.

This modified bluish background grants a color balance for improved visual representation of overlaid information. Figure 4a depicts a scene with physical objects, and Figure 4b depicts a bird vision's simulation. Stretching the color spectrum leads to a high contrast scene with a blue-tinged background and yellowish emissions reflected from the physical objects. The yellowish emissions enable the strong highlighting of particular information in the scene on particular physical objects. This highlighting is not lost in the clutter of the background, and the highlighting is visible at further distances from the user than traditional AR highlighting methods. The bluish background enables the user to view the surrounding environment, and this view is comfortable and safe for the user to move through the environment and manipulate the physical objects.

Figure 4: Horus Eye's vision. (a) Original camera scene (b) Simulation to the bird vision, using RGB (c) Adopted bird vision simulation for Horus Eye, using YUV.

Figure 5: Snake vision representation. (a) Original camera scene (b) The result of "high sugar" query (c) The result of "high fat" query.

Birds have a separate cone that is responsible for the ultraviolet wavelength. They also have a less sensitive contrast factor than humans [10], enabling them to detect the regions of interest through light, useful for information tasks such as finding, or filtering. Perceiving the simulated bird's vision with our three cones (RGB) results in color bleeding, which might be confusing for information blending. To remove the color bleeding's effect, we simulated the bird vision through the YUV color space (see Figure 4c). We also experimented with changing the background into a grey scale image. The grey scale images were not as effective as a background to contrast with the highlighted information. We applied a number of different colors for the emission reflections, and none of these were as effective as both of the bird vision methods. This was determined through informal evaluation.

3.2 Snake Vision

A snake's vision is infrared sensitive, enabling them to visualize the radiated heat from warm bodies. They can determine the heat's value from the color's brightness. The snake's vision is contrast-based, showing a promising potential to using it for data representation, as a quantitative representation. Contrast and illumination sensitivity are well known in the visualization literature [10] as one of the strengths of a human's vision. This cueing method provides potentialities for AR visualization presentations. The high contrast between the bluish background and the reddish glowing can enhance the colors' perception, and highlight the data clearly. Figure 5 depicts the Horus Eye snake visual representation on supermarket products. The color reflects a percentage value of the physical object's ingredient, which is selected by a user query. This technique extends the concept of the bird vision technique to add a quantitative value to the highlighted information. An example of the snake vision is depicted in Figure 5b showing the colors based on a "high sugar" query where the products with high sugar are shown with brightest values, and Figure 5c shows the colors based on a "high fat" query, showing that "belvita" has high fat and low sugar content; the "continental soup", has low sugar and high fat; and "Blasts" has high content in both.

3.3 Horus Lens

Figure 6 presents three adapted approaches using contrast, illumination, and objects' pose based snake vision visualization. Figure 6a shows the use of a color-coded technique combined with a contrast technique. This combined approach can be deployed to clustering to enhance information visualization. Figure 6a shows a

Figure 6: Snake vision adaptations. (a) Illumination and contrast (b) Heatmap (c) Wedjat.

resulting visualization from a user query of ”low sodium and Australian made”, using green glowing to highlight the Australian made products and the contrast visualization used for the rest of products. Figure 6b depicts a second adaptation for the data visualization, using a heat map to show the object’s overview information to represent users’ ratings of the product’s individual parts such as the nutritional health indications, or the user’s flavor rating. Overloading multiple data representations is one of the needs for information representation, such as clustering the product based on Australian made and showing the “salt content”. Figure 6c introduces a new approach interaction called the “Wedjat,” to support overloading the object by multiple representations. The user can tilt to check if it is Australian made, and view it vertically to see the “salt content.” This natural transition gives users different perspective views. We used cubemaps to alters the visualization based the physical objects’ pose.

The Horus lens is a context-based brightness filter. Vision filters are well-known approaches for information visualization, such as Gaussian filter [3], or fish eye [8]. The Horus lens uses an illumination filter instead of the blurring filter, as the brightness of the scene and the focal point dynamically change based on the overview information, leveraging the lower interest zones for abstract visualization. For instance, if users chose the ”healthy shopping” parameter, the view will be brighter at the vegetable aisles more than at the potato crisps aisles.

Figure 7 shows the Horus lens technique, as the brightness value and focal point are calculated based on the user query (see Figure 7a), it also shows the abstract data registered on the darker zone of the scene. If the user approaches the shelf or selects a product, the visualization changes to the detailed view by increasing the brightness value (Figure 7b). The transition between the different views is controlled by depth distance between the camera, the physical objects and the user’s query.

Figure 7: Horus lens. (a) Abstract view with context based brightness value and focal point (b) A detailed view mode.

Figure 8: Object bars technique. (a) Object bars using the real scene’s object textures (b) Object bars using a snake representation. (c) Object bars with color-coding for clustering.

3.4 Object Bars

Flying is one of the main Horus’s powers, allowing him to see different perspectives, which inspired us to use the third dimension to support our data representation, expanding the viewing perspectives. Object bars technique converts the physically tracked objects to a bar chart. The representation canvas is the depth area between the camera and the tracked objects. The physical objects construct the bar chart, by extending perpendicular to the face of the box. The main contribution of this technique is to avoid contextual information masking the physical objects by using the objects themselves to construct the representation. A camera ray-cast is used to calculate and update the available canvas size based on the distance between the camera and the physical objects

The Horus Eye's high-contrast property supports the object bars technique with multiple options for data representations. Figure 8a show the object bars technique employed on a bird vision background. This visualization has resulted from a "High sodium content" query. Figure 8b depicts a combination of snake vision technique and the object bars technique to overload multiple data in the same bar's representation. The bar's color represents the value of the "high sodium content" query and the bar's length represents the value of the "low cost" query. Figure 8c shows a color-coding approach for overloading the object bars with clustering results. The bar's length represents the value of the "high sodium content" query, and the green color used to highlight the "healthy criteria" group, the blue color uses to highlight the "Australian made products" group and the red colors used to highlight the "others". Figure 9 depicts the use of transparency and object bars for individual object's data representations based on the user query such as: "energy content" (Figure 9a), "sugar content" (Figure 9b), or "sodium content" (Figure 9c).

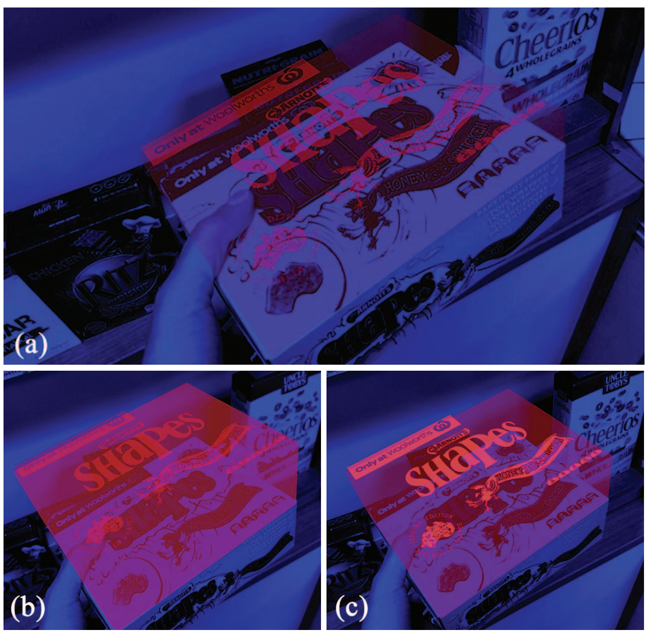

Figure 9: Object bars query results using transparency. (a) The energy content. (b) The sugar content. (c) The sodium content.

3.5 The Missing Keystone

This section represents a computational analytical visualization approach, which we called "Keystone", as it locks the whole visualizations together. Keystone represents the analytical functions' output, such as nutrition equations in the shopping context. It is a context-based computational analytical visualization locking the whole technique together. The technique is inspired by the missing 1/64 fraction owned by Horus, which was the understanding (Figure 2b). Keystone provides virtual cues, based on the contextual awareness. These cues are presented with a limited ratio, to avoid scene's cluttering. Figure 1c shows the keystone, by merging the virtual cues which are green highlighting for Australian made products and a star point nutrition [7] iconic representation to show the health value of the selected product based on the user's profile and daily intake. The concept of keystone requires further investigations.

Figure 10: Different adaptation for Horus eye. (a) Real scene (b) Black-light adaptation (c) Horus Eye (d) Black/white adaptation.

4 Future Work

We are continuing to develop visualization techniques that are inspired by the Horus concept to support information visualization. These include bird vision, snake vision, Horus lens, object bars, and keystone.

The foundation is the bird vision concept model that is based on a large illumination difference between the background and the foreground elements. However, humans can detect more patterns based on contrast. Through formal evaluation we would like to answer the questions: *Is the bird vision technique suitable for humans with the missing ultraviolets cone?*

There are two potential adaptations for the Horus Eye; Blacklight (see Figure 10b) and Black/White (see Figure 10d) with different contextual masking effect. The black-light approach masks the real scene more than Horus Eye, but it might enhance the perception of the virtual information, especially from long distances. While the black/white approach encompasses the real scene's contextual information more than Horus Eye, it limits the representation options due to the lack of the high contrast value. Initial informal testing indicated this approach does work as well as our Horus Eye techniques, but we would like to explore this further.

Our further investigation will evaluate the Horus Eye technique against the similar approaches, and also with the two adopted approaches black-light and black/white, to examine the benefits of each approach and to implement a smooth transition between the three approaches, allowing users to invoke them based on their preferences.

5 Conclusion

This paper presents a set of novel visualization techniques for AR information representation, using high contrast scene: bird vision, snake vision, Horus lens, object bars, and keystone. By leveraging the contextual features of the physical objects to highlight the information presented, we have demonstrated some potentially useful techniques. Our approach blends the virtual data into the real scene to reduce the visual clutter challenge of AR and makes the highlighting cue visible at further distances. Our proposed technique is a context-based approach and controlled by the user's interactions. This paper presents a work in progress that will be further evaluated through user studies, comparing the Horus eye with its two adapted versions and with the existing approaches.

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References

[1] D. Benyon, O. Mival, and S. Ayan. Designing blended spaces. In *Proceedings of the 26th Annual BCS Interaction Specialist Group Conference on People and Computers*, pages 398–403. British Computer Society, 2012.

[2] O. Bimber and B. Frohlich. Occlusion shadows: using projected light to generate realistic occlusion effects for view-dependent optical see-through displays. In *Mixed and Augmented Reality, 2002. ISMAR 2002. Proceedings. International Symposium on*, pages 186–319. IEEE, 2002.

[3] G. Deng and L. Cahill. An adaptive gaussian filter for noise reduction and edge detection. In *Nuclear Science Symposium and Medical Imaging Conference, 1993., 1993 IEEE Conference Record.*, pages 1615–1619. IEEE, 1993.

[4] N. ElSayed, B. Thomas, K. Marriott, J. Piantadosi, and R. Smith. Situated analytics. In *Big Data Visual Analytics (BDVA), 2015*, pages 1–8. IEEE, 2015.

[5] N. A. ElSayed, B. H. Thomas, K. Marriott, J. Piantadosi, and R. T. Smith. Situated analytics: Demonstrating immersive analytical tools with augmented reality. *Journal of Visual Languages Computing*, pages –, 2016.

[6] N. A. ElSayed, B. H. Thomas, R. T. Smith, K. Marriott, and J. Piantadosi. Using augmented reality to support situated analytics. *Virtual Reality (VR)*, 2015.

[7] L. M. Fischer, L. A. Sutherland, L. A. Kaley, T. A. Fox, C. M. Hasler, J. Nobel, M. A. Kantor, and J. Blumberg. Development and implementation of the guiding stars nutrition guidance program. *American Journal of Health Promotion*, 26(2):e55–e63, 2011.

[8] G. W. Furnas. *Generalized fisheye views*, volume 17. ACM, 1986.

[9] A. Gardiner. Egyptian grammar. griffith institute, ashmolean museum, 1957.

[10] M. M. Ghim and W. Hodos. Spatial contrast sensitivity of birds. *Journal of Comparative Physiology A*, 192(5):523–534, 2006.

[11] T. H. Goldsmith. What birds see. *Scientific American*, 295(1):68–75, 2006.

[12] L. Gruber, D. Kalkofen, and D. Schmalstieg. Color harmonization for augmented reality. In *Mixed and Augmented Reality (ISMAR), 2010 9th IEEE International Symposium on*, pages 227–228. IEEE, 2010.

[13] D. Kalkofen, E. Mendez, and D. Schmalstieg. Interactive focus and context visualization for augmented reality. In *Proceedings of the 2007 6th IEEE and ACM International Symposium on Mixed and Augmented Reality*, pages 1–10. IEEE Computer Society, 2007.

[14] D. Kalkofen, C. Sandor, S. White, and D. Schmalstieg. Visualization techniques for augmented reality. In *Handbook of Augmented Reality*, pages 65–98. Springer, 2011.

[15] R. Kooper and B. MacIntyre. The real-world wide web browser: An interface for a continuously available, general purpose, spatialized information space. 2000.

[16] T. Langlotz, T. Nguyen, D. Schmalstieg, and R. Grasset. Next-generation augmented reality browsers: rich, seamless, and adaptive. *Proceedings of the IEEE*, 102(2):155–169, 2014.

[17] P. Lensing and W. Broll. Fusing the real and the virtual: a depth-camera based approach to mixed reality. In *Mixed and Augmented Reality (ISMAR), 2011 10th IEEE International Symposium on*, pages 261–262. IEEE, 2011.

[18] V. Lepetit, M.-O. Berger, and L.-I. Lorraine. An intuitive tool for outlining objects in video sequences: Applications to augmented and diminished reality. *tC*, 2:t3, 2001.

[19] M. A. Livingston, J. E. Swan II, J. L. Gabbard, T. H. Höllerer, D. Hix, S. J. Julier, Y. Baillot, and D. Brown. Resolving multiple occluded layers in augmented reality. In *Proceedings of the 2nd IEEE/ACM International Symposium on Mixed and Augmented Reality*, page 56. IEEE Computer Society, 2003.

[20] H. Slay, M. Phillips, R. Vernik, and B. Thomas. Interaction modes for augmented reality visualization. In *Proceedings of the 2001 Asia-Pacific Symposium on Information Visualisation - Volume 9*, APVis '01, pages 71–75, Darlinghurst, Australia, Australia, 2001. Australian Computer Society, Inc.

[21] B. Thomas, K. Grimmer, J. Zucco, and S. Milanese. Where does the mouse go? an investigation into the placement of a body-attached touchpad mouse for wearable computers. *Personal Ubiquitous Comput.*, 6(2):97–112, Jan. 2002.

[22] E. Veas, R. Grasset, I. Ferencik, T. Grünewald, and D. Schmalstieg. Mobile augmented reality for environmental monitoring. *Personal and ubiquitous computing*, 17(7):1515–1531, 2013.

[23] S. Zollmann, D. Kalkofen, C. Hoppe, S. Kluckner, H. Bischof, and G. Reitmayr. Interactive 4d overview and detail visualization in augmented reality. In *Mixed and Augmented Reality (ISMAR), 2012 IEEE International Symposium on*, pages 167–176. IEEE, 2012.