



A CRITICAL REVIEW OF THE PRESENT AND FUTURE PROSPECTS FOR ELECTRONIC PAPER

***OFUALAGBA MAMUYOVWI HELEN; & **OMAMOKE
LAYEFA**

*Department of Computer Science, Delta State Polytechnics Otefe, Oghara, Delta State. **Department of computer science, University of Africa Toru-orua Sagbama, Bayelsa State

Abstract

Electronic paper display techniques are ways or style in which electronic paper display devices apply to mimic the appearance of ordinary ink on paper. Electronic paper display is also called E-paper display or EPD. E-paper is capable of holding text and images indefinitely without drawing electricity or using processor power, while allowing the paper to be changed. Most importantly, the state of each pixel can be maintained without a constant supply of power. E-paper can become an essential tool for future products on a large scale as the world tend to rely more and more on technology, having lightweight devices with long battery life. From the questionnaires raised with respect to the awareness and use of E-papers, it was concluded that in the nearest future, there will be a rise in the use of E-paper and a high reduction in the use of conventional papers.

Introduction

Electronic paper display techniques are ways in which electronic paper display devices apply to mimic the appearance of ordinary ink on paper (Wikipedia, 2010) Electronic paper display is also called E-paper display or EPD. It is a display device that possesses a paper-like high contrast appearance, ultra-low power consumption, and a thin, light form. It gives the viewer the experience of reading from paper, while having the power of updatable information. Unlike a conventional flat panel display, which uses a backlight to illuminate its pixels, electronic paper reflects light like ordinary paper and is capable of holding text and images indefinitely without drawing electricity or using processor power, while allowing the paper to be changed. One important feature is that the state of each pixel can be maintained without a constant supply of power. (WikiAnswers, 2011)

The primary substance used in the electronic paper display is electronic ink (Comiskey, 1998.) Electronic Ink is the main material that is processed into a film for combining into electronic displays. Electronic ink is the result gotten from the combination of physics, chemistry and electronics to create electronic displays. The basic components of electronic ink are millions of tiny micro-capsules, about the diameter of human hair. Each micro-capsule, in one incarnation contains positively charged white particles and negatively charged black particles put in a clear fluid.

The positive white particles move to the top of the micro-capsule where they become visible to the user when a negative electric field is applied. This makes the surface visible as white spot. At the same time, an opposite electric field pulls the negative black particles to the bottom of the micro-capsules where they are hidden and are not visible. If this process is reversed, the negative black particles appear at the top of the capsule, which now makes the surface appear dark at that spot (Sheridon, N. 2007). To form an Electronic Paper Display, the ink is printed onto a plastic film sheet that is laminated to a layer of circuitry.

Statement of problem

IT managers are rightly wary of conventional displays, this is because Production problems often led to LCD shortages, forcing hardware vendors to miss shipments and raise prices. Most recently, Apple computer was forced to reorganize its product strategy, releasing its CRT-based. One of the more common problems with conventional display is the potential for stuck pixels, where the pixel does not receive a voltage and remains black. Or it does not respond to voltage changes and stays at a set luminance level. Because of these challenges there is need to switch to e-paper technology

Aim and objectives of the Study

The aim of the study is to critical review of the present and future prospects for electronic paper. The objectives of the study are to;

- i. Review of e-paper display techniques, types of electronic paper display techniques and area their applications
- ii. Review of the working principle of e-paper display
- iii. Questionnaires on the awareness and the rate of use of electronic paper.

Related Literature

According to (Genuth, 2007), Gyricon was the first e-paper developed in 1970s at Xerox's Palo Alto Research Centre. It is composed of polyethylene spheres of about 75 to 106 micrometers across. Each sphere (Janus particle) is composed of black plastic on one side and white plastic on the other which is negatively and positively charged respectively. In a transparent silicone sheet these spheres are embedded, with each sphere dispersed in a bubble of oil so that every sphere can spin freely. The applied voltage polarity to each pair of electrodes determines whether the black or white side is face-up, hence giving the pixel a white or black look. (Dejean, D. (2008).

In the 1990s another type of electronic paper was invented by Joseph Jacobson, who later co-founded the corporation E Ink which formed a partnership with Philips Components two years later to develop and market the technology. Using this technology, Japanese company Soken has established a wall with electronic wall-paper at the FPD 2005 exhibition.

E-PAPER DISPLAY TECHNIQUES

Electronic paper display techniques are ways or style in which electronic paper display devices apply to mimic the appearance of ordinary ink on paper. Electronic paper display is also called E-paper display or EPD. (Crowley, J. M.; 2002) It is a display device that possesses a paper-like high contrast appearance, ultra-low power consumption, and a thin, light form. It gives the viewer the experience of reading from paper, while having the power of updatable information. Unlike a conventional flat panel display, which uses a backlight to illuminate its pixels, electronic paper reflects light like ordinary paper and is capable of holding text and images indefinitely without drawing electricity or using processor power, while allowing the paper to be changed. (Heikenfeld, R. (2011). One important feature is that the state of each pixel can be maintained without a constant supply of power.

TYPES OF E-PAPER DISPLAY TECHNIQUES

The techniques for e-paper display are as follows:

I. ELECTROPHORETIC DISPLAYS (E.G. E INK)

Electrophoretic displays from, for instance, E-Ink, contain millions of tiny microcapsules. These microcapsules are filled with a clear fluid having small particles of different colors and electric charges. On applying a positive charge, negatively charged particles move to the top, and positively charged particles

move to the bottom of the microcapsule and vice versa. This movement of the particles to the top and bottom makes the surface display a specific color (Otani, T. 2008.).

II. ELECTROWETTING DISPLAYS (E.G. ETULIPA)

Etulipa is one of the companies employing electrowetting display technology, which uses the liquid's surface tension to create electrowetting displays. An electrowetting display contains several tiny cells of transparent polar liquid and colored oil covering a hydrophobic surface. The oil contracts into a small droplet by applying a low voltage to the cells. It then creates an open or closed optical switch capable of displaying text, art, photos, or even video (Akwukwuma, V. 2012)

III. ELECTROCHROMIC DISPLAYS (E.G. YNVISIBLE)

Electrochromic displays are produced using electrochromism, a process where material changes color when applying an electric current. The electrochromic material undergoes chemical oxidation and reduction on applying voltage in the presence of an electrolyte. This results in a color change, which can be finely tuned. Ynvisible's electrochromic displays are ultra-energy-efficient, and one coin cell battery can power them for around 50 years. Ynvisible's displays are produced using screen-printing processes that are highly scalable and cost-effective, making them a more cost-effective solution to other e-paper technologies (Anderson, P., D 2002).

Method adopted in the study

In the course of carrying out this research, two methodologies was adopted; firstly the exploratory research method was adopted, this is described as research conducted to explore an area not yet properly understood. This research method facilitates the process for carrying deeper comprehensive reviews on the current trend of the topic of discuss. The questionnaire research methodology was also adopted, about 200 questionnaire was developed and shared among individuals working in different spheres of life, out of these shared questionnaire, one hundred and ninety six (196) were filled and returned, five out of the one hundred and ninety six (196) were not properly filled and two were lost during the compilation process. At the end one hundred and eight nine (189) were used for analysis and conclusion.

COMPARISON OF E-PAPER DISPLAY AND LCD

Electronic Paper Display (EPD)	Liquid Crystal Display (LCD)
Large viewing angle	Best image visible only from one position
Black on white paper	Gray on gray
Readable in sunlight	Difficult to see in sunlight
Can hold image without power drain	Required power to hold images
Made of plastic or glass	Glass only
Light Weight	More heavy due to Power supply and glass make
Thin(~1 mm)	Thick (~7 mm)

ADVANTAGES OF USING E-PAPER DISPLAY

The advantages are:

- I. Paper-like readability.
- II. Sunlight and non-uniform light visibility.
- III. High reflectivity, high contrast & resolution.
- IV. Viewing angle ~180 degree.
- V. Highly flexible.
- VI. Ultra Low Power Consumption.
- VII. Long-term Bi-stable Image content preserved without power.
- VIII. Prolonged battery life.
- IX. Capable of color & video.
- X. Clarity.
- XI. Reduced Eyestrain.

DISADVANTAGES OF USING E-PAPER DISPLAY

The disadvantages include:

- I. Very low switching speed.
- II. Electrochemical complexity.
- III. Slow response to change.

- IV. Too slow for video.
- V. Difficult to read in low lightning condition.
- VI. Contrast ratio is poor as compared to LCD, LED and Plasma Displays.

SAMPLE OF QUESTIONNAIRE DEVELOPED AND USED

1. Have you heard of Electronic paper or electronic note book? (Yes or No)
2. Have you used Electronic Paper? (Yes or No)
3. How well are you conversant with using Electronic paper? (< 40%/ 41% to 50%/51% to 79%/ Above 80%)
4. How frequently do you use Electronic paper? (< 40%/ 41% to 50%/51% to 79%/ Above 80%)
5. Is using electronic paper convenient for you than conventional papers? (Yes/No)
6. Is electronic paper easily accessible to you than the conventional paper? (Yes/No)

Table 1 gives the outcome from the questionnaire that was given out and Figure 1 gives a graphical representation in percentage of the outcomes from the different questions asked.

Table 1: Table showing the outcome from the Questionnaire

Question	Yes	< 40%	41% to 59%	60% to 79%	Above 80%
Question 1	167	22			
Question 2	180	9			
Question 3		30	25	102	32
Question 4		60	42	75	12
Question 5	114	75			
Question 6	120	69			

From the findings in table one, it is clear that lots of persons have great knowledge of electronic paper and can make good use of it but it is clear that a little larger population are yet to adapt the usage of the electronic paper fully while yet a few are still struggling

with accepting its usage together with the convenience of using the electronic paper. Some part of the population is still having difficulty in having access to this electronic paper. Also, from the chat in figure 1, it is very clear that more percentage of individuals have used and are conversant with using electronic paper.

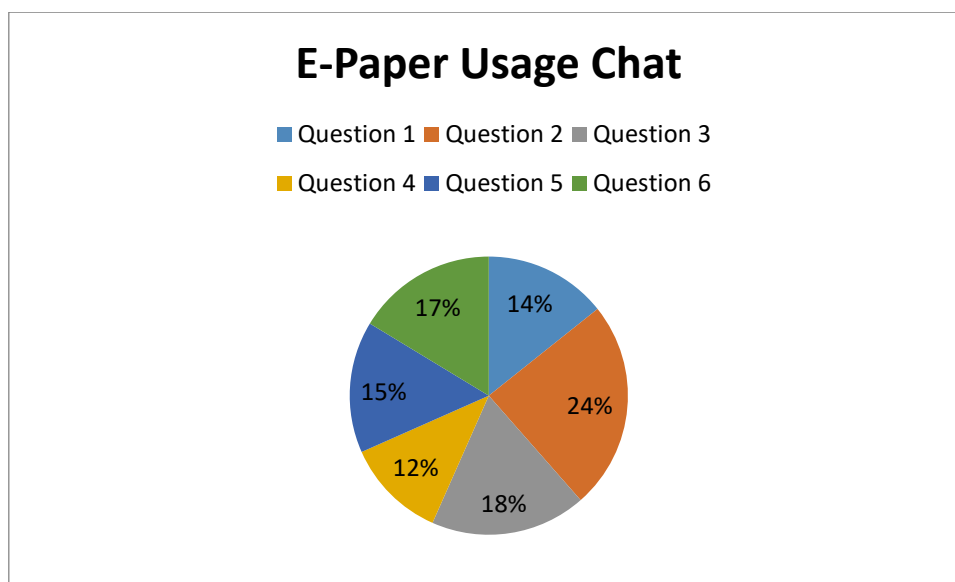


Figure 1: Chat showing the Percentage of the Findings

CONCLUSION

Conclusively, with the rapid development of high-speed wireless communication and cloud computing, we have entered the era of ubiquitous networks. Wherever people are, they are surrounded or accompanied by display devices, such as smart phones, tablets, notebooks and advertising screen, there is a tendency that more people will embrace the usage of electronic paper. Finally, e-paper displays are the displays of the future because they are very energy efficient, truly portable and can be used universally in various fields in which electronic displays haven't ventured till now. Without no doubt, it can also be assumed that in the nearest future, these display techniques will eventually replace paper and lead us to a "paperless" world.

REFERENCES

- Akwukwuma, V.V.N. and F.O. Chete. 2012. —Electronic-Paper: The Electronic Display of the Future. *Pacific Journal of Science and Technology*. 13(2):173-180. Retrieved 22/01/2023
- Anderson, P., D. Nelson, P. Svenson, M. Chen, A. Malonstrom, T. Remonem, T. Kugler, M. Berggren. 2002. —Active Matrix Displays based on All-organic Electrochemical Smart Pixels Pointed on Paper. *Adv Mater* 2002. 14(20):1460-1464. Retrieved 10/02/2023

- Comiskey, B.; Albert, J. D.; Yoshizawa, H.; Jacobson, J. (1998). An Electrophoretic Ink for All Printed Reflective Electronic Displays. *Nature* 1998, 394, (6690), 253-255: Alison Park, USA. Retrieved 23/01/2023
- Comiskey, Barrett; Albert, J. D.; Yoshizawa, Hidekazu; Jacobson, Joseph (1998). "An electrophoretic ink for all-printed reflective electronic displays". *Nature*. 394 (6690): 253– 255. doi:10.1038/28349. ISSN 0028-0836 Retrieved 22/01/2023
- Crowley, J. M.; Sheridan, N. K.; Romano, L. (2002). Dipole Moments of Gyricon Balls of Electrostatic: Juwish publish, USA. Retrieved 23/01/2023
- Dejean, D. (2008). The Future of E-Paper. Jet-publish unit: Newyork, USA. Retrieved 23/01/2023
- Genuth, I. (2007). Innovative Storage Capacity Meter with Electronic Paper Display from E-ink: Capital city, London. Retrieved 15/01/2023
- Heikenfeld, R. (2011). Advantages and Disadvantages of E-paper Display Techniques: Avaro, Mexical City. Retrieved 16/01/2023
- Otani, T. 2008. Soken Shows off Twist Ball Type E-paper Covering a Full Wall. Retrieved 15/01/2023 from <http://techonikkobp.co.jp/english/NEWSEN/20081104>
- Sheridon, N. (2007). The Future of Electronic Paper. Brooklyn Press: Downtown, USA. . Retrieved 20/01/2023 from <http://www.thefutureofthings.com/articles>
- WikiAnswers (2011). Advantages of Electronic Paper. Retrieved 22/01/2023 from <http://www.enwikipedia.org/wiki/electronic-paper>.
- Wikipedia. 2010. —Electronic Paper. Retrieved 22/01/2023 from <http://www.enwikipedia.org/wiki/electronic-paper>.