MemoriLens: a Low-cost Lifelog Camera Using Raspberry Pi Zero

Quang-Linh Tran
ADAPT Centre, School of Computing,
Dublin City University
Dublin, Ireland
linh.tran3@mail.dcu.ie

Binh Nguyen
University of Science,
Vietnam National University
Ho Chi Minh City, Vietnam
ngtbinh@hcmus.edu.vn

Gareth J. F. Jones
ADAPT Centre, School of Computing,
Dublin City University
Dublin, Ireland
gareth.jones@dcu.ie

Cathal Gurrin
ADAPT Centre, School of Computing,
Dublin City University
Dublin, Ireland
cathal.gurrin@dcu.ie

ABSTRACT

Lifelogging is the process of automatically logging data about an individual's daily life, which can then be used in various domains, such as behavior analysis and health monitoring. Various technological devices, including wearable cameras and smartwatches, can help record lifelog data, but getting access to lifelog cameras has proven difficult in recent years, due to a lack of such devices on the market. Creating a lifelog camera that is not only easy to use and cost-efficient but also provides comprehensive functions to log all images about life is challenging due to the lack of hardware and software. This paper introduces MemoriLens, a low-cost camera that efficiently collects, organizes, and stores lifelog data using a readily available custom-designed Raspberry Pi Zero board. The camera is designed to capture images automatically and send them to a private account in cloud services for storage. We open-source the implementing of the camera at: https://github.com/linh222/raspberry_lifelog_camera and we encourage lifelog researchers to use our designs and software as required.

CCS CONCEPTS

• **Hardware** → Sensor devices and platforms.

KEYWORDS

Lifelogging, lifelog camera, personal multimedia archive

ACM Reference Format:
Quang-Linh Tran, Binh Nguyen, Gareth J. F. Jones, and Cathal Gurrin. 2024. MemoriLens: a Low-cost Lifelog Camera Using Raspberry Pi Zero. In *Proceedings of the 2024 International Conference on Multimedia Retrieval (ICMR '24), June 10–14, 2024, Phuket, Thailand*. ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3652583.3657592

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ICMR '24, June 10–14, 2024, Phuket, Thailand
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ACM ISBN 979-8-4007-0619-6/24/06.
https://doi.org/10.1145/3652583.3657592

1 INTRODUCTION

Lifelogging is the process of automatically collecting, and processing data about a person's life experience [4, 9]. The data combines various sources, including images/videos, audio, health metrics, web browsing, etc. Visual lifelog is images or videos taken from the point of view (PoV) of lifeloggers [8] which is an important source of lifelog data. This data can provide useful insight into the lifeloggers thanks to the rich content. There is a wide range of purposes for utilizing lifelog data, ranging from healthcare monitoring [1, 18] to memory support [2, 3, 10], and lifelog retrieval [15, 16]. Visual lifelog plays a significant role in supporting healthcare monitoring. Zhou et al [18] conducted an experiment on assessing children's food intake using wearable cameras and suggested that wearable cameras promise to improve the accuracy of dietary intake assessment. Another major application of lifelog is retrieval for memory support. Lifelog retrieval relates to retrieving lifelog images and metadata about a moment in the past that can help lifeloggers reminiscence the memory they already experienced. Some benchmark challenges have been organized to utilize visual lifelog for lifelog retrieval such as Lifelog Search Challenge [7] and NTCIR Lifelog Task [17]. These works prove the importance of visual lifelog in a wide range of applications so there is a requirement for a low-cost, available and robust wearable lifelog camera.

A variety of lifelog cameras have been developed for the purpose of logging PoV images. Microsoft SenseCam [6, 11, 12] was created by Lyndsay Williams and a team at Microsoft, as a wearable camera to capture up to 2000 lifelog images per day. A lot of subsequent similar products such as Autographer[1], and Narrative Clip[2] were produced for commercial applications in the early 2010s. However, it is worth noting that these cameras are no longer available on the market. The Autographer was stopped in production in December 2014 while the Narrative Clip ceased production in late 2016 due to cashflow problems and a broad decline in venture capital interest [3]. The shortage of these lifelog cameras makes lifeloggers need a new camera to log their life moments. A very popular action camera now on the market is GoPro [4] which can capture videos and images at a high quality. However, a GoPro capability is too redundant to passively log acceptable-resolution images. In addition, the price

[1]www.autographer.com
[2]http://getnarrative.com/
[3]http://blog.getnarrative.com/2016/10/an-open-letter/
[4]https://gopro.com

of a GoPro is high, compared to a lifelog camera only. With the development of technology, single-board computers are becoming increasingly small and powerful [13] and at the same time, camera technology is producing better quality and lower cost camera sensors. Inheriting the concept and general functions of the lifelog cameras, as well as the availability of technological devices, we create MemoriLens lifelog camera from a low-cost Raspberry Pi Zero board and the latest Raspberry Camera Module 3[5]. To the best of our knowledge, there are no readily available lifelog cameras on the market that can provide the end-to-end functionality that can capture high-quality lifelog images and upload them to a private account in cloud services. This work is a foundation for a comprehensive lifelog system to support lifeloggers from collecting, storing, browsing, searching and ultimately understanding their life.

2 DESIGN AND IMPLEMENTATION OF MEMORILENS

2.1 Camera Hardware

We use Raspberry Pi Zero as the core component of the camera. It is a single-board computer (SBC) produced by the Raspberry Pi Foundation[6]. We choose to use the Raspberry Pi Zero version due to its readily available, cost-effectiveness, relatively small size, and low energy consumption [5]. With 512GB of RAM and a 1GHz single-core GPU, the board effectively balances energy consumption and performance requirements for image capturing and processing. Additional sensors such as GPS modules, barometer, motion sensor, etc can be incorporated into this board. These sensors provide a large amount of data for logging the activity of lifeloggers, but we mainly focus on visual lifelog so the board is only attached with a camera module. The board is attached with an 1850 mAh lithium battery and PiJuice Zero power platform to keep the camera operating smoothly without any energy corruption. The camera can operate continuously for 8 hours with a capture rate of 2 images per minute.

The Raspberry Camera Module 3[7] is the latest camera from the Raspberry Pi Foundation, which uses a 12MP IMX708 Quad Bayer sensor. The Camera Module 3 can capture images with resolutions up to 4608×2592 pixels. The camera enhances the fast auto-focus capability, allowing high-quality image capture even when in motion, which is important for any lifelog camera. The Raspberry Camera Module 3 is connected to the Raspberry Pi Zero through a camera cable. To accommodate the Raspberry Camera Module 3, we re-design an open-sourced[8] case to make the case bigger and cover the lens. The illustration of the camera is depicted in figure 1 below.

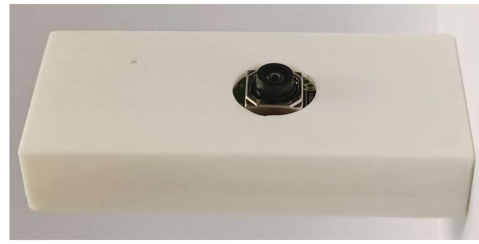

Figure 1: Illustration of the camera

2.2 Camera Software

The camera's operating system (OS) is Raspbian Lite OS 32bit with no desktop environment. This OS also supports Python development so we can customize the camera to accommodate the requirements for a lifelog framework from the level of security to the basic and advanced functions of image capturing. We use the package libcamera[9] to perform the task of capturing images. We use the crontab command to run the job of capturing images at regularly scheduled intervals. Some configurations are set to get the best quality images. The exposure mode is sporting, which means a short exposure time to prevent the blurred image during movement. The high dynamic range (HDR) is turned on to improve colour quality. The auto-focus feature is exploited with the fast speed and full range focus to capture clear images. All these configurations are from experiments in real-world environments. The software to run the camera is published on Github at: https://github.com/linh222/raspberry_lifelog_camera. We also implement the uploading services to a remote server through scp[10] command and/or Amazon AWS S3[11].

2.3 Implementation and Testing

MemoriLens is worn in front of the chest utilizing a chest mount. This follows research by Mayol-Cuevas et al. [14] indicating that the chest is the best place to wear a lifelog camera. We have tested MemoriLens in several typical everyday environments to ensure that it works well, namely indoors, outdoors with direct sunlight, and outdoors in shaded conditions. Figure 2 shows three examples of images from these three environments. All these images have satisfactory brightness levels and exceptional details. In figure 2a, the words on the screen can be read, so it may be necessary to implement screen-blurring (or face-blurring) if privacy is a concern. Figure 2b is captured in an outdoor environment with direct sunlight, thanks to it, the image quality is exceptional with clear objects and colour. When we zoom in on that image, we can clearly see two people and a dog on the field, which proves great details can be captured by MemoriLens. Figure 2c is captured in an environment with both shadow and light, posing a challenge for the camera to balance the light. However, the quality and light of the image are good with great details even in shadow.

We also perform a comparison in image quality between our camera MemoriLens and the AutoGrapher camera. Figure 3 illustrates two pictures captured by AutoGrapher and MemoriLens at the same time with the same camera position. Because MemoriLens is featured with a wide-lens camera, that makes the picture from it has a bigger view than its counterpart. In general, the image quality of the picture from MemoriLens is better than the picture from AutoGrapher. To be specific, the brightness of the image from

[5]https://www.raspberrypi.com/
[6]https://www.raspberrypi.com/
[7]https://www.raspberrypi.com/products/camera-module-3/
[8]https://cults3d.com/en/3d-model/tool/raspberry-pi-zero-camera-case
[9]https://libcamera.org/getting-started.html
[10]https://manpages.ubuntu.com/manpages/trusty/en/man1/scp.1.html
[11]https://aws.amazon.com/pm/serv-s3

(a) Indoor **(b) Outdoor with direct sunlight** **(c) Outdoor in shaded conditions**

Figure 2: Lifelog images from the camera in different environments

(a) AutoGrapher **(b) MemoriLens**

Figure 3: Lifelog images from the Autographer vs MemoriLens cameras

MemoriLens is greater than the image from AutoGrapher, although both of them are captured at the same time on a cloudy day. MemoriLens automatically adjusts the brightness to capture the image with the best brightness while AutoGrapher cannot adapt to the light and capture the overwhelming brightness of the sky with very low brightness in the lower scene. In addition, the image details of the picture from MemoriLens are better with clear objects. The resolution of the picture from MemoriLens is higher than the picture from AutoGrapher so that can explain the higher image details. After testing the camera in various environments, we finally configured all the settings in the camera and provided the technical specifications of the camera as in the table 1.

CPU	Raspberry Pi Zero
Image Sensor	Raspberry Camera Module 3 (IMX708)
Sensor Resolution	11.9 megapixels
Sensor Size	7.4 mm sensor diagonal
Horinontal/Vertical	4608x2592 pixels
Lens	Wide - 120 degrees diagonal field
Image resolution	1280x720, 1920x1080, 2560x1440, 4096x2160
Battery	RS Pro, 3.7V, Lithium Polymer Rechargeable Battery, 2Ah, 1850 mAh (Optional)
Battery Time	Charge Time: 2 hours Use Time: 8 hours
Dimensions (WxHxD)	80 x 40 x 35 mm
Weight	62 g
Power Control and Real-time Clock	PiJuice Zero

Table 1: Technical specifications of MemoriLens

2.4 Data Storage and Organization

Amazon AWS S3 is a simple but efficient cloud service to store data. All lifelog images and data are initially stored in a bucket in S3. The data is organized by date, meaning all images and metadata on the same day are stored in a folder with the folder name as the date. Amazon S3 supports accessing lifelog images and data by URL so we can use the link to access data. Another storage option is saving data on any remote server. The camera can use the SCP command to upload images to the remote server through SSH.

2.5 Limitations

Although MemoriLens hold many advantages such as being cost-efficient, easy to use and requiring simple configuration, there are still a lot of limitations on this camera. Firstly, although the camera supports auto-focus ability, the nature of passive capturing images creates a challenge in capturing images when lifeloggers are moving. The movement of lifeloggers makes the camera capture blur images. Some examples of blurred pictures are depicted in figure

(a) Lifelogger is holding a moving object

(b) Lifelogger is walking

Figure 4: Blurred lifelog images

4. Although the level of blurriness is not significant, it still poses some challenges in image processing and object detection. Secondly, the dimensions and weight of the camera are a bit heavier than previous commercialized lifelog cameras. This camera is more in line with the size of the commonly used AutoGrapher in research, but bigger than the general-purpose Narrative Clip which is now discontinued production. The reason for this is the size of the Raspberry Pi Zero board and the weight of the battery. Given the fact that a Pi is a general-purpose computing device, it is necessary to trade-off between the battery time and the weight of the camera, but the camera should operate for at least 8 hours to meet the need for lifelogging a day so we use 1850 mAh battery. In comparison, the Narrative Clip used a sub 350 mAh battery. Finally, as the lens is only a wide lens, it cannot work well in a low-light environment. We can use the Raspberry Pi Camera Module 3 NoIR to accommodate this drawback and it can be easily changed with the current lens in MemoriEase to solve this limitation.

3 CONCLUSION

In this paper, we introduce the MemoriLens camera, a low-cost camera to capture lifelog images. This camera shows advantages in using low-cost hardware for constructing cameras and optimising the software to capture high-quality lifelog images. This camera can capture images every pre-defined time period and upload lifelog images to cloud services for storage and utilization. Although the camera works well in various environments, there is still room for improvement in making the camera better at capturing in-motion images, and in low-light environments. In the future, we will develop the camera and incorporate it with a lifelog retrieval system to create an end-to-end system to support lifeloggers for logging and capturing images.

ACKNOWLEDGMENTS

This research was conducted with the financial support of Science Foundation Ireland at ADAPT, the SFI Research Centre for AI-Driven Digital Content Technology at [University Name] [13/RC/21-06_P2]. For the purpose of Open Access, the author has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

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