OpenLifelogCam – A Low-Cost Open-Source Wearable Camera Platform

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ABSTRACT

The capture and subsequent analysis of egocentric imagery in the form of Lifelogs can be useful in several application areas. However, suitable hardware to record such data is not always available or can be cost-prohibitive. This paper introduced the OpenLifelogCam, an open-source hardware wearable camera platform that is designed to be customizable enough to cover a broad range of possible applications while being as cheap as possible to construct even in low volumes.

CCS CONCEPTS

• **Hardware** → Sensor devices and platforms; • **Information systems** → *Specialized information retrieval*; • **Computing methodologies** → *Image and video acquisition.*

KEYWORDS

Lifelogging, Wearable Camera, Autobiographical Multimedia, Data Collection Devices, Open-Source Hardware

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1 INTRODUCTION

With the steadily growing ubiquity of low-cost and low-power sensing and computing devices, we can increasingly gather more data about the world and ourselves. While a large portion of such autobiographical data is collected for social and entertainment purposes, it can also be put to several other uses. The process of *Lifelogging* describes the *"process of passively gathering, processing, and reflecting on life experience data collected by a variety of sensors"* [2]. Such *Lifelogs* can contain data from different sensors. The most information-dense of these sensor streams are generally produced by wearable cameras, capturing the world from the Lifelogger's point of view at regular intervals. Data collected by such wearable cameras has been shown to be useful for various applications, including memory augmentation [1, 6] and healthcare [3–5].

In recent years, several dedicated devices that capture visual information from a first-person perspective have become commercially available. Targeted towards consumers, wearable camera devices such as the *Spectacles*[1] by Snap or Smartglasses[2] resulting form a collaboration between Ray-Ban and Meta enable wearers to capture images and video. These devices are, however, not designed for passive continuous recording but rather for the active and user-directed capturing of specific moments, often with a social aspect of photo and video sharing platforms in mind. They are, therefore, not ideally suited for continuous passive recording. Additionally, being directed towards a more affluent market segment can make their use cost-prohibitive for various applications. While dedicated lifelogging cameras such as the Narrative Clip[3] were produced in the past, no such device is currently commercially available.

To address the availability of suitable devices for lifelog collection, this paper introduces the OpenLifelogCam, an open-source lifelogging camera that can be easily and cheaply assembled from readily available components and customized for different application cases. In its default configuration, OpenLifelogCam has an operational lifetime of 12-13 hours per charge and can be built for about 20 USD in component cost for a single unit with a rapidly decreasing unit cost for only slightly larger batch sizes. The components have been selected for high availability and low cost, making OpenLifelogCam at least an order of magnitude cheaper than dedicated consumer devices such as those mentioned above, trading off some image quality in the process. Build instructions and firmware files for the OpenLifelogCam are available via https://github.com/lucaro/OpenLifelogCam.

The remainder of this paper introduces OpenLifelogCam's components and their interplay in Section 2 and describes their operation in Section 3. Section 4 then discusses some applications and limitations of OpenLifelogCam, followed by some concluding remarks in Section 5.

2 COMPONENTS

The following presents the main components of OpenLifelogCam, illustrates their interrelation, and discusses the bill of materials and cost breakdown.

2.1 Component overview

OpenLifelogCam consists of the following components:

ESP32-Cam The ESP32-Cam serves as the base component of OpenLifelogCam. It is a small development board built

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[1]https://www.spectacles.com
[2]https://www.ray-ban.com/usa/ray-ban-meta-smart-glasses
[3]http://getnarrative.com/

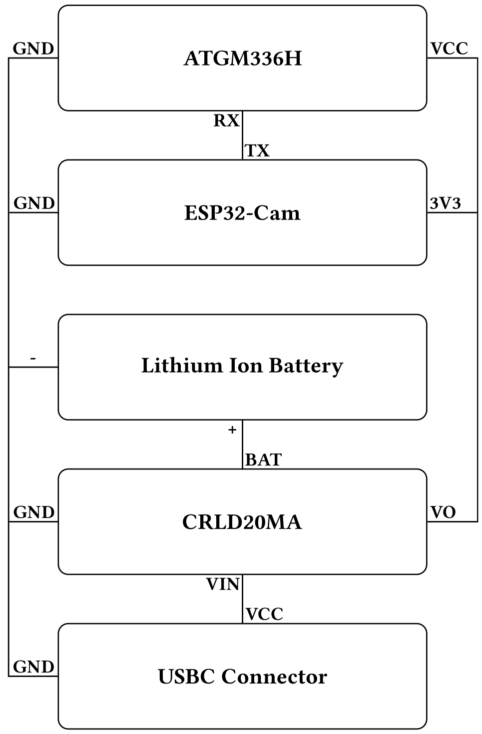

Figure 1: Component connection diagram for OpenLifelog-Cam

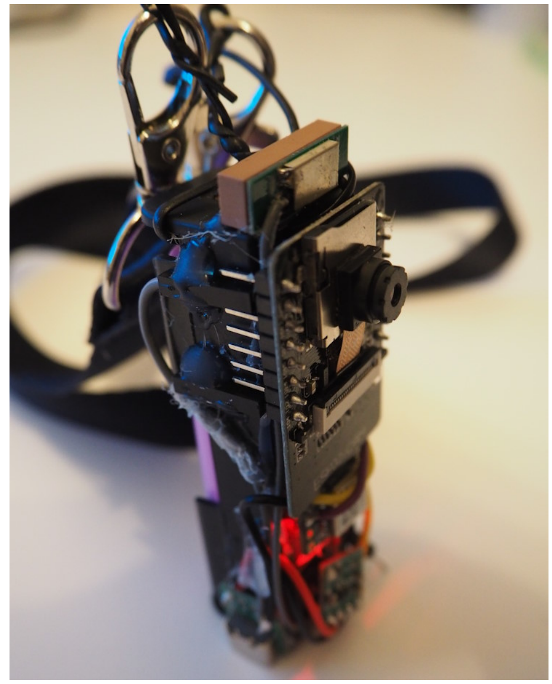

Figure 2: OpenLifelogCam without housing

around an Expressif ESP32-S microcontroller with two 32-bit cores operating at 160MHz. The ESP32 series of microcontrollers were originally developed as low-cost wireless interfaces for other devices and come equipped with both Wifi and Bluetooth radios, neither of which are used in this application. Due to their versatility and low cost, this family of microcontrollers has become quite popular in the open-source hardware community. The ESP32-Cam board includes a microSD card holder and the supporting peripherals and connector for a Serial Camera Control Bus (SBBC) camera module.

Omnivision 2640 Camera Sensor The OV2640 is a 2-megapixel CMOS camera sensor with a maximum image resolution of 1600×1200 pixels. It communicates through an SBBC interface and is the default image sensor for the ESP32-Cam board.

ATGM336H The ATGM336H is a global positioning receiver module supporting the GPS, GLONASS, Galileo, and BDS navigation satellite constellations. It uses a UART interface to transmit messages about its current time and location in the plain-text NMEA 0183 format. It is used as a source for both time and positioning information by OpenLifelogCam.

CRLD20MA The CRLD20MA is a combined LiIon battery charging and 3.3v voltage regulator circuit, designed for low-power low-cost applications.

18650 Lithium Ion Battery In its default configuration, Open Lifelog Cam uses a single 18650 lithium-ion battery cell with 3500 mAh capacity, giving it a runtime of 12-13 hours. The 18650 format is chosen because it is one of the most common battery form factors, used in everything from consumer electronics to electric cars, and hence readily available. It has the additional benefit that the diameter of such a battery cell is just slightly smaller than the width of the ESP32-Cam board, enabling an efficient arrangement of components.

microSD card The microSD card is used as a persistent storage location to save the recorded images. Due to limitations in memory and compute resources of the ESP32, a FAT32 filesystem is used.

2.2 Component interplay and build instructions

In addition to the components listed above, only connectors for the battery and external power sources for charging, such as a USBC port, are required. Figure 1 shows a diagram of how the components are connected.

In addition, a small modification to the ESP32-Cam board is necessary. The board includes a bright LED for illumination purposes that is not used in our application. Since the LED shares a pin that is also used for the interface to the SD card, accessing the SD card causes the LED to flicker. To avoid this, the LED needs to be disconnected by cutting a connecting board trace or removing the LED entirely. Figure 2 shows the device in its default configuration.

2.3 Cost breakdown

Affordability and availability were the main selection criteria for the OpelLifelogCam components. All components can be obtained in small to single-unit qualities from online marketplaces such

Table 1: Approximate cost breakdown for primary components of the OpenLifelogCam in batch sizes of 1, 5, and 10, excluding component shipping costs.

Component	1x	5x	10x
ESP32-Cam	$5.00	$25.00	$50.00
ATGM336H Positioning Module	$4.20	$21.00	$42.00
18650 E35 Lithium Ion Cell	$4.30	$11.70	$14.50
18650 Cell holder	$0.40	$2.00	$4.00
CRLD20MA Charge Controller	$2.90	$2.90	$5.80
USB connector	$0.90	$0.90	$0.90
MicroSD card	$2.90	$14.50	$29.00
Batch cost	$20.60	$78.00	$146.20
Unit cost	$20.60	$15.60	$14.62

as aliexpress.[4] Table 1 shows the approximate component costs for batch sizes of 1, 5, and 10 units, respectively. Due to regional variabilities, shipping costs are excluded. Some of the components were not available in single-unit quantities. In these cases, the costs for the smallest available unit were used. Consumables such as connecting wires, solder, or adhesives for mounting the components are not accounted for in this estimate.

3 OPERATION

During operation, OpenLifelogCam follows a fixed sequence of steps. Upon initial startup, the SD card is mounted, and the optional configuration file is read, if available. This file enables some parameters, such as the picture interval and some camera settings, to be adjusted. Afterwards, the current time is queried from the positioning module. Since the positioning module can take up to 30 seconds to receive initial information from a satellite, even under ideal conditions, and possibly even longer if walls block satellite signals, OpenLifelogCam will wait up to 2 minutes to determine the current clock time. If no time information can be obtained within these two minutes, a fallback value will be used. Once the time information is obtained, the internal clock is configured accordingly. After this initialization phase, the first picture is taken. To train the automatic exposure and white balance mechanism of the OV2640 sensor, a configurable number of images is taken and discarded before the image is saved. During the saving procedure, the EXIF information is augmented with the current time and, if available, positioning information. After the image is saved, a sleep time is computed based on the configured capture interval, and the ESP32 is put into deep sleep mode to conserve power. The sleep time is slightly foreshortened to allow some time for initialization before the next picture is to be taken.

When the controller again awakes from its sleep period, it checks for updates from the positioning module concerning time and location. It then waits until the exact time for the following picture and repeats the process.

Each picture takes up on the order of 100kb of storage space. Assuming a capture interval of 3 images per minute and an SD card size of 32Gb allows for roughly 2 months of uninterrupted image capture, assuming OpenLifelogCam is charged regularly. Using its default configuration of one 3500mAh 18650 battery and three pictures per minute results in an operational time of 12-13 hours per charge. If longer uninterrupted periods or similar periods with higher capture rates need to be supported, a larger capacity battery must be used.

[4] https://aliexpress.com

Figure 3: Image captured outdoors in rainy weather

Figure 4: Image captured outdoors in sunny weather

4 APPLICATIONS AND LIMITATIONS

Figures 3–5 show examples of images captured by OpenLifelogCam in various conditions. While the image quality is not on par with state-of-the-art digital cameras, the images are generally of sufficient quality to be useful for many applications. While Lifelog datasets have so far been limited to the perspective of a single Lifelogger, the low-cost nature of OpenLifelogCam could enable larger data-collection efforts with several participating Lifeloggers. This could open up new avenues for insights gleaned from multiple different perspectives on the same situations.

The low-cost nature of the device does, however, also bring some limitations, some of which are illustrated in Figures 6–8. The

Figure 5: Image captured indoors under artificial light

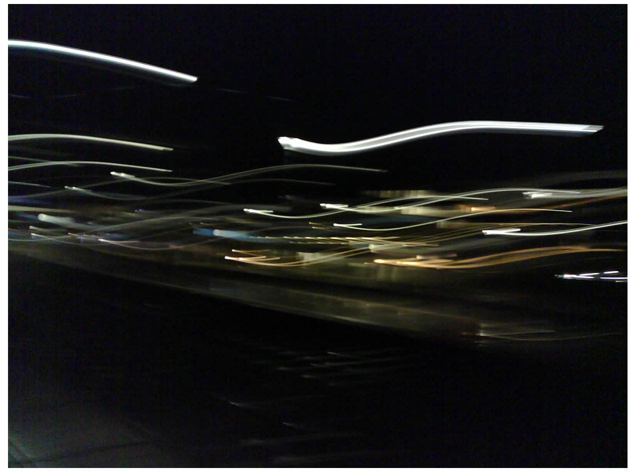

Figure 7: Picture with excessive motion blur in a low-light condition

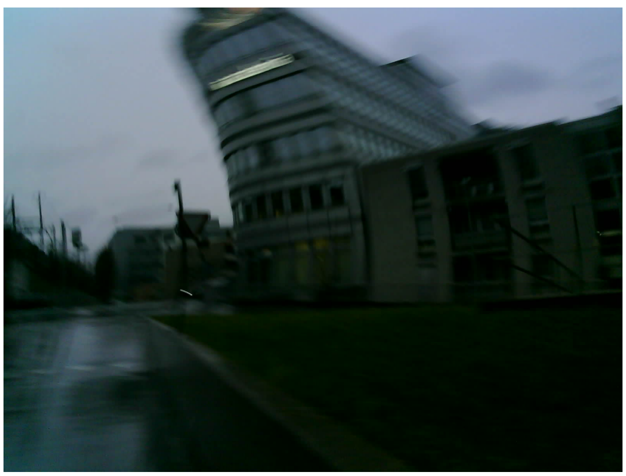

Figure 6: Picture with motion blur

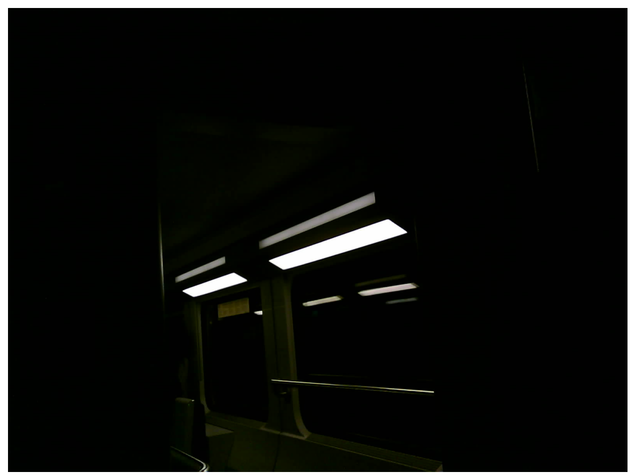

Figure 8: Picture with insufficient dynamic range

comparatively long capture time of the used image sensor can lead to substantial motion blur if the device is in motion during image capture (see Figure 6). This effect can be exacerbated in low-light conditions, as shown in Figure 7 or if the device is worn in a way that might cause a pendulum effect. Another drawback of the used sensor is its limited dynamic range, illustrated in Figure 8. Some of these limitations could possibly be overcome by different sensor settings, taking more images to train the automated exposure and white balance mechanisms, taking pictures at a higher rate to compensate for poor captures, or performing offline image post-processing. Except for the last option, which would be performed off-device, all these options would increase the power consumption of the device, lowering battery lifetime or requiring more battery capacity.

5 CONCLUSION

This paper introduced the OpenLifelogCam, an open-source wearable camera platform optimized for availability and low cost. OpenLifelogCam can easily be constructed even in low unit volumes and enables customization for a wide range of use cases. Our aim is that this device will make Lifelog data collection more accessible to a larger audience, enabling them to benefit from the many downstream applications of personalized data collection.

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REFERENCES

[1] Cathal Gurrin, Klaus Schoeffmann, Hideo Joho, Andreas Leibetseder, Liting Zhou, Aaron Duane, Duc-Tien Dang-Nguyen, Michael Riegler, Luca Piras, Minh-Triet Tran, Jakub Lokoč, and Wolfgang Hürst. 2019. Comparing Approaches to Interactive Lifelog Search at the Lifelog Search Challenge (LSC2018). *ITE Transactions on Media Technology and Applications* 7, 2 (2019), 46–59. https://doi.org/10.3169/mta.7.46

[2] Cathal Gurrin, Alan F. Smeaton, and Aiden R. Doherty. 2014. LifeLogging: Personal Big Data. *Found. Trends Inf. Retr.* 8, 1 (2014), 1–125. https://doi.org/10.1561/1500000033

[3] Rebecca Nourse, Susie Cartledge, Teketo Tegegne, Cathal Gurrin, and Ralph Maddison. 2022. Now you see it! Using wearable cameras to gain insights into the lived experience of cardiovascular conditions . *European Journal of Cardiovascular Nursing* 21, 7 (06 2022), 750–755. https://doi.org/10.1093/eurjcn/zvac053

[4] L. N. Signal, J. Stanley, M. Smith, M. B. Barr, T. J. Chambers, J. Zhou, A. Duane, C. Gurrin, A. F. Smeaton, C. McKerchar, A. L. Pearson, J. Hoek, G. L. S. Jenkin, and C. Ni Mhurchu. 2017. Children's everyday exposure to food marketing: an objective analysis using wearable cameras. *International Journal of Behavioral Nutrition and Physical Activity* 14, 1 (Oct. 2017), 1–11. https://doi.org/10.1186/s12966-017-0570-3

[5] Teketo Kassaw Tegegne, Ly-Duyen Tran, Rebecca Nourse, Cathal Gurrin, and Ralph Maddison. 2024. Daily Activity Lifelogs of People With Heart Failure: Observational Study. *JMIR Form Res* 8 (21 Feb 2024), e51248. https://doi.org/10.2196/51248

[6] Ly-Duyen Tran, Manh-Duy Nguyen, Duc-Tien Dang-Nguyen, Silvan Heller, Florian Spiess, Jakub Lokoc, Ladislav Peska, Thao-Nhu Nguyen, Omar Shahbaz Khan, Aaron Duane, Björn Þór Jónsson, Luca Rossetto, An-Zi Yen, Ahmed Alateeq, Naushad Alam, Minh-Triet Tran, Graham Healy, Klaus Schoeffmann, and Cathal Gurrin. 2023. Comparing Interactive Retrieval Approaches at the Lifelog Search Challenge 2021. *IEEE Access* 11 (2023), 30982–30995. https://doi.org/10.1109/ACCESS.2023.3248284