# Development of Programmable Camera-Trap

Mehmet Karakose[#1], Canan Tastimur[*2], Selim Özdemir[#3], Merve Erol[#4], Ahmet Tokgoz[#5], Erhan Akin[#6]

[#]Firat University, Department of Computer Engineering, Elazig, Turkey
[#]Erzincan Binali Yildirim University, Department of Computer Engineering, Erzincan, Turkey

***Abstract*** *The monitoring of wildlife, especially in large areas, has great difficulties in terms of time, personnel and resources. Different methods and alternatives have been tried to be developed to overcome these difficulties. One of these methods is the camera trap devices. Camera trap devices are used for wildlife monitoring and security reasons. As a result of the widespread use of camera trap, a programmable camera trap device was designed in this study. The developed camera trap device has some advantages over camera trap in the market. In this work, the development of a programmable photo trap for the monitoring of endangered animals and illegal human activities is proposed. In this study, the movement in the area to be monitored is detected by IR rays and the camera is activated. After the camera is activated, the monitored media is photographed. Then, the captured image was compressed and sent to the monitoring center via GSM / GPRS line. One of the advantages of the developed camera trap device is that it provides superiority in cases where the speed of sending the captured photo to the monitoring center should be high. Another one is that, according to camera trap systems, the image can be taken instantly by tolerating the expected time to wake up the device and take the picture, as it instantly saves the image. Because the photo traps are used in the rural area, speed optimization for energy and intervention events has been studied and as a result a different photocopier devices have been designed.*

**Keywords —** *Camera, Photo trap, Programmable, Surveillance, Wild environment.*

## I. INTRODUCTION

The decrease in wild animal species caused by humans and natural disasters is observed. Like all other living things, wild animals are the cornerstone of the ecosystem in which they are located. Conservation of these species is of great importance to ensure the continuity of live life. Continuous monitoring and control of wildlife pose great difficulty in terms of land, personnel, and resources. Especially in difficult terrain conditions, intensive vegetation-covered areas, and species that appear at night, these species have to be monitored by the camera [1-3]. Because of these difficulties, photo trap systems are used for wildlife monitoring, species identification, species counting, protection of endangered animals, and monitoring of a species in more than one area.

Digital Photo traps used in wildlife research and management are remote devices that automatically record images or videos of animals passing by them. With the reduced cost, widespread availability, and ease of use of photo traps, it offers the potential to accumulate enormous amounts of data compared to traditional methods. It is observed that photo traps produce accurate, robust, and ecologically meaningful data by taking them quickly and using them widely. As a research tool, photo trap is now used in various applications. It is used to explore the habitats and distribution of species, to collect demographic data and to protect endangered species. Photo traps are used for purposes such as the population status of wild species, examining their behavior, and identifying endangered species.

The most important reason for the use of photo traps is the elimination of the economic, personnel, and time loss that will be caused by continuous and simultaneous observation at different points. Photo traps usually come in two types: heat-sensitive photo traps and motion-sensitive photo traps. There are many studies applied in the literature to develop photo traps. Soininen et al. [4] designed a camera traps to measure the activity of small mammals. The testing of the developed device was carried out with nine camera traps with passive infrared sensors in an environment where the snow cover lasted about six months. Leflore [5] automatically triggered photo traps that were used to evaluate the distribution of jackals, red foxes, and gray foxes around a particular area. Behnke [6] exemplified the heterogeneous workspace by placing photo traps in ninety different locations throughout the rainy and dry seasons using photo traps with passive sensors.

Eichholzer [7] 681 photos were obtained from camera traps in order to obtain information about the presence of wild cats. The applicability of these cat pictures required cats to be correctly identified as wild cats or pets. Nazir et al. [8] designed a user-customizable open-source camera trap platform called 'WiseEye' to provide a flexible camera trap technology for wildlife research. This platform includes a Raspberry Pi single-board computer and compatible peripherals that allow the user to control the functions and performance. Thom [9] created a study that automatically detects animal species by using digital images from photo traps in the Arctic tundra region. Hendry and Mann [10] produced open-source software to manage photo trap survey data. Wang [11] has provided an animal species identification system that can automatically identify the species of an animal caught in an image with the aid of a photo trap.

## II. THE PHOTO TRAP DEVICES

Photo traps are systems that contain sensors and remote access cameras are used to monitor wildlife [12-19]. Photo traps are used for various purposes such as observing wildlife, detection of endemic species, and security [15]. By using photo traps at different points at the same time, both personnel costs are eliminated and the accuracy rate desired to be achieved is increased. In parallel with the development of technology, the use of photo traps has become widespread with the increase in camera resolution rates and the use of various sensors. An example photo trap image is shown in Fig 1.

**Fig 1: An example camera trap [20]**

There are some issues to be considered in the selection of photo trap systems. Thanks to these points that need to be considered, unnecessary components are prevented from increasing the cost of the system, the system is well understood and its requirements can be determined well. Attention should be paid to the presence of a night vision system and the use of cameras with low energy requirements in the choice of photo traps. The energy consumption of the cameras working with the infrared system in the night vision system is less than the consumption of flash cameras. The more the camera's width is, the more it will capture the image within that area, which will increase the accuracy of the system. The viewing angle of the camera should be mounted so that the image can be captured at the points where the wild animal can pass.

The trigger speed of the camera should be as minimum as possible. It is generally preferred to be less than two seconds. The minimum shooting speed of the camera will contribute to the performance of the system. The fast sending of the photo sent to the image center is of great importance in some areas depending on the usage area [21]. For sending data, there should be options such as MMS, GPS / GPPRS, internet if possible. Since the regions where photo-capping systems are used are generally deserted and forested areas, the images are recorded primarily on the memory card on the processor, and the transmission of the acquired images to a control center and the server is usually provided over the phone line via GPS / GPRS.

### A. *Working System of Photo traps*

Photo traps, in general terms, have two types of working mechanisms. These are active sensor photo traps and passive sensor photo traps. With the help of a transmitter that emits infrared rays in photo traps with active sensors, this device is placed in areas where the target type passes. On the opposite side of the device are the receivers that receive the data obtained by the camera-trap. The working principle of photo traps with active sensors using infrared rays can be expressed as taking a photo by activating the camera when a living creature passes through the area affected by infrared rays [22, 23]. In passive sensor photo traps, there are cameras and various sensors in a single package. Photographing takes place with the passage of a living species in the observed area with the information received from these sensors.

### B. *Photo-trap Installation Process*

There are some points to be considered during the assembly process of photo traps. The viewing angle of the camera should be a cross-sectional view of the area. If the camera viewing angle is perpendicular, it is likely that the animal being monitored will exit the camera field of view until the image is taken, and this situation is not recommended. Said camera viewing angle placement rule is expressed in Fig. 2. If the area where the camera trap will be used has a sloping structure, the camera trap should be placed at an oblique angle. By placing the camera at an inclined angle, it will be ensured that the image in the monitored area is obtained completely.

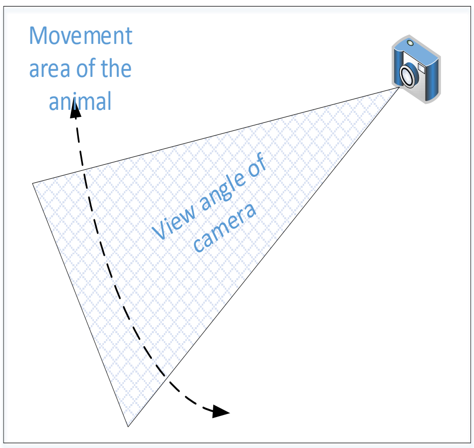


**Fig 2: View angle of camera trap**

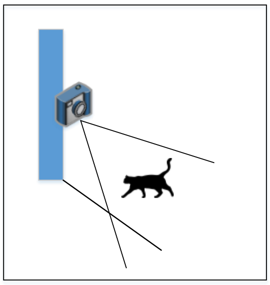

**Fig 3: Installing the photo-trap camera at an inclined angle**

It should be noted that the device does not receive direct sunlight when placing photo traps. Overheating of photo traps devices that receive excessive sun rays can cause the device to malfunction and to run out of battery life [20].

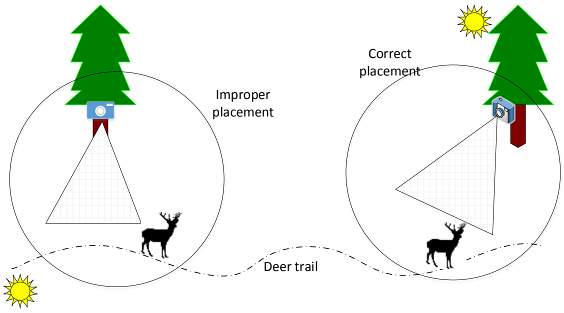


**Fig 4: Photo-trap camera placement rule**

The coordinates where the photo trap systems are placed should be recorded. In order to protect the photo trap device against seasonal conditions and animal attacks, photo trap devices should be stored in protection containers.

## III. RECOMMENDED PHOTO-TRAP DESIGN

The most important advantage of the camera trap system developed in this study is the speed of camera photo shooting and photo transmission. For the proposed camera trap design, Orange Pi Plus 2e was used as the development card and Olivetti Webcam was used as the camera. The camera in this developed system works in video mode. The photo frame in the camera is recorded as soon as motion is detected.

The recorded image is sent to the image monitoring center by applying compression on the Orange Pi plus 2e development card. The purpose of the image compression process is to reduce the size of the image and to send the image more quickly by using image compression algorithms to tolerate the slowing of the transmission speed against the increased image quality. Huffyuv, Msu Lossless video codec, RLE, CT, Mpeg-4, etc. for image compression process. methods are used [24]. There are also supported compression algorithms for many languages for image compression. For example, Pillow Library provides compression of images in Python language. In this study, the Pillow library was used for compression.

The image compression process is transferred to the SIM900 device. The image to be transferred has been converted to Base64 format to be sent to the monitoring center via HTTP protocol. This sent image is given to the Android device as an instant notification. Since the advantage of this system compared to other camera trap systems is recording the image instantly, the image can be taken instantly by tolerating the expected time to wake up the device and take the picture. It is more convenient to use for application areas where the transmission speed is important. The disadvantage of this developed system is that it consumes more energy because it operates in the camera trap video mode. The block diagram of the steps to be applied for the proposed camera trap design is summarized in Fig. 5.

In this study, the Embedded Linux system has been designed. Since it will take a long time to design our own device, it is aimed to write a system suitable for the existing development card and the device to be built. Software components to be used in the embedded system design to be developed; Cross Compilation, Bootloader, Linux Kernel, C Library, and applications. Cross-compilation runs on the development board but can generate code for the target device. The bootloader is responsible for loading hardware resources and is the part of provisioning. Linux Kernel manages processes and memory. It also contains device drivers and allows user area applications. Library C forms the interface between the kernel and the user area.

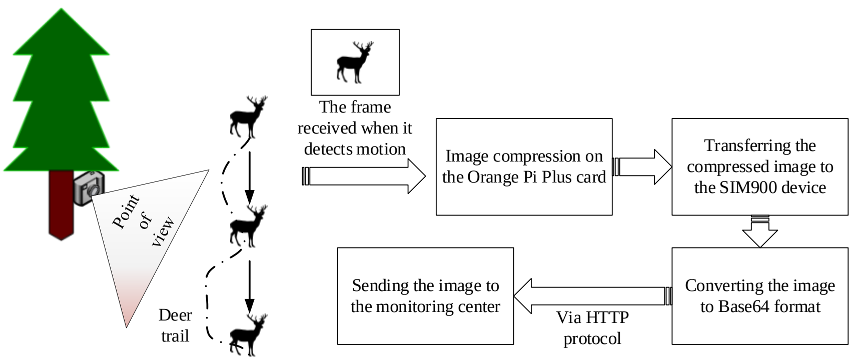


**Fig 5: Block diagram of the proposed method**

In the proposed method, the Cross compilation tool, Linux system, and bootloader are used. Toolchain tools are used in cross-compilation processes. The toolchain is a set of tools that includes a compiler, linker, and runtime libraries that compile the source code into executable files that can run on the target device. In this study, a tool that adequately meets the requirements has been selected in determining a pre-compiled Toolchain tool. Features such as the family of the processor owned by the development card and the C library should be taken into consideration. The development card we use in the proposed method includes the Ubuntu operating system and the ARM family processor. Toolchain has been chosen in accordance with the features mentioned in this study. After the completion of these preparations, the Linux kernel has been prepared. The reason for using the Linux kernel is that it can perform tasks such as managing hardware resources on a system, providing simultaneous access to hardware resources, and using user applications with hardware resources. The version of Linux, which will be used primarily in the process of preparing the Linux kernel, is downloaded from the internet. The preferred Linux version in this study is Mainline 4.11. Steps applied during the preparation of the Linux kernel are installation, configuration, compilation, and installation. The flow chart below summarizes this process.

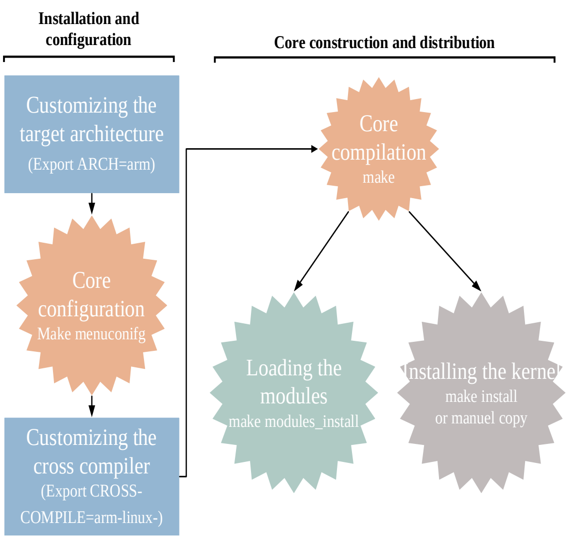


**Fig 6: Preparation process of Linux kernel**

While configuring the Linux kernel, the necessary selections have been made as shown in the graphical interface below. The necessary settings can be made by selecting the processor type and family, boot options on this menu.

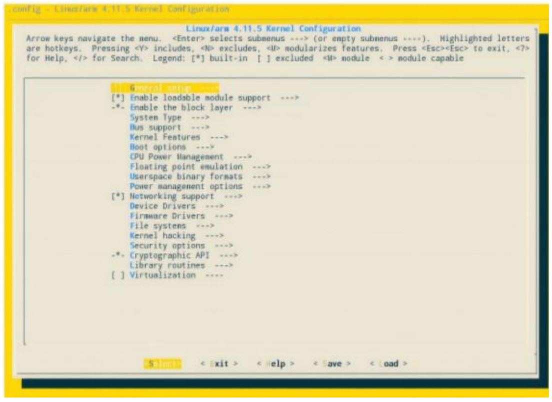

**Fig 7: Configuration step of Linux kernel**

As a result of the configuration process of the Linux kernel, Kernel Image files were created. After this process, the installation process of the modules was applied. Then the Linux kernel was booted with U-Boot. Parameters for resetting the boot delay time, loading the zImage file to the address in the memory, and ensuring the boot from the RAM address provided with Bootz are selected for the boot process. With the support of Buildroot cross-compilation, it is provided to automate the Linux system creation process. Thus, we can design an operating system that will work on the Arm architecture. The selection process in Fig. 8 has been applied to determine the target architecture via Buildroot.

In this study, it is important to install Python and serial packages since we want to communicate the Python programming language with the sim900 through the serial connection interfaces of the card. Apart from this, the python-pillow package for image compression operations and the fswebcam package that provides video API support for the webcam have been selected.

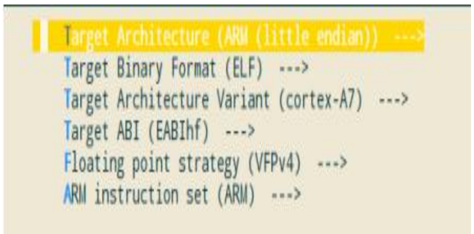


**Fig 8: Selecting the properties of the target architecture**

In the Linux kernel configuration, the driver models that we want to be on the kernel are selected. Then, since the hardware to be used on the Linux interface development card should be selected, the input/output units required by the hardware we specified in the requirement analysis were selected. In this study, the communication system with the device was installed externally. For this reason, only the UART pins are processed. Ethernet, Wireless, Infrared, Bluetooth, Audio / Video, SPI, I2C, etc. to

Linux kernel. Modules of the support have been added.

After the configuration process was completed, the compilation process started with the Buildroot tool. When the compilation process is over, the image file of the entire system required for us was prepared in the output folder. The preparation of the embedded system is completed by writing this file on the SD card. After the operating system starts, the device needs to be set up to act as a camera. Init services start when the Linux operating system starts. Accordingly, in this study, a shell script was created in the /etc/init.d/ the directory that Busybox package offers to users to write init services since our priority service is the camera.

Once the camera module is installed, it will be defined on the device /dev/video attached to the USB interface. Loading the camera module 1.5 sec. Due to the time it took, the system has held until the camera saw the state that the device was available. The system here checks the status at 100 ms intervals. As soon as the camera is available, the system takes the photo and records the photo with the determined timestamp. Immediately after taking the photo, the system activates the GSM module and transmits it. In order to keep the processing time as short as possible and to reduce the energy consumption of the device, energizing the device is performed at boot time and the GPRS connection is completed until the photo-taking time.

## IV. CONCLUSIONS

The camera trap devices are used for wildlife monitoring and security reasons. As a result of the widespread use of photo traps, a programmable photo traps device was designed in this study. The developed camera trap device has some advantages over camera trap in the market. One of these advantages is that the developed camera trap device excels in situations where the speed of sending the captured photo to the viewing center should be high. Another one is that, according to camera trap systems, the image can be taken instantly by tolerating the expected time to wake up the device and take the picture, as it instantly saves the image. This developed device is more suitable to be used for application areas where transmission speed is important. The disadvantage of this developed system is that it consumes more energy because it operates in camera trap video mode. In the developed camera trap system, the camera works in video mode. When motion is detected, the image of the video at the moment of detection (frame) is subjected to sending with SIM900. The video is recorded in Mkv format using the FFmpeg library. Since the video shooting is active in the background, the process of taking the image is much faster than taking the photo. The images obtained from the device are sent to the server via SIM900 and the user is informed with Push Notification. In addition, the user is informed that a picture is sent via a text message. In the developed system, the working time of the PIR sensor is 0.2 seconds, the working time of Orange Pi Plus 2e is 0.8 seconds, the time it takes to take the image from the camera, and send the photo to SIM900 is 2 seconds. Thus, the total time spent by the system has been calculated as 3 seconds.

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## REFERENCES

[1] Y Uçarlı ve B Sağlam, "*Yaban Hayatı Çalışmalarında Camera trap Kullanımı*". Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi, 2013; 14(2): 321-331.

[2] FA Pamplin, "*Optimising the value of by-catch from Lynx lynx camera trap surveys in the Swiss Jura Region*". M.S. thesis, University of East Anglia, Norwich, England, 2013.

[3] OR Wearn and PG Kapfer, "*Camera trapping for conservation: a guide to best practice*". WWF Conservation Technology Series, 2017; 1(1).

[4] EM Soininen., I Jensvoll, ST Killengreen, and RA Ims, "*Under the snow: a new camera trap opens the white box of subnivean ecology*". Remote Sensing in Ecology and Conservation, 2015; 1(2): 29-38.

[5] GE Leflore, "*Assessing Wild Canid Distribution Using Camera Traps in the Pioneer Valley of Western Massachusetts*". M.S. thesis, Dept. Environmental Conservation University of Massachusetts Amherst, Amherst, United States, 2014.

[6] R Behnke, "*A camera-trap based inventory to assess species composition of large- and medium-sized terrestrial mammals in a Lowland Amazonian rainforest in Loreto Peru: a comparison of wet and dry season*". M.S. thesis, University of Bodenkultur Wien, Wien, Austria, 2015.

[7] A Eichholzer, "*Testing the applicability of pictures taken by camera-traps for monitoring the European wildcat Felis silvestris silvestris in the Jura Mountains of Switzerland*". M.S. thesis, University of Zürich, Zürich, Switzerland, 2010.

[8] S Nazir, S Newey, R Irvine, F Verdicchio, P Davidson, G Fairhurst, ve R Van Der Wal, "*WiseEye: Next generation expandable and programmable camera trap platform for wildlife research*". PloS one, 2017; 12(1).

[9] H Thom, "*Uni1ed Detection System for Automatic, Real-Time, Accurate Animal Detection in Camera Trap Images from the Arctic Tundra*". M.S. thesis, The Arctic University of Norway, Tromso, Norway, 2017.

[10] H Hendry and C Mann, "*Camelot--Intuitive Software for Camera Trap Data Management*". bioRxiv, 2017.

[11] B Wang, "*Automatic Animal Species Identification Based on Camera Trapping Data*". M.S. thesis, University of Alberta, Alberta, Canada, 2014.

[12] A Miguel, J Beard, C Bales-Heisterkamp, and R Bayrakcismith, "*Sorting camera trap images*". 2017 IEEE Global Conference on Signal and Information Processing; 2017; Canada: 249-253.

[13] C Zhu, T Li, and G Li, "*Towards Automatic Wild Animal Detection in Low Quality Camera-Trap Images Using Two-Channeled Perceiving Residual Pyramid Networks*". IEEE Conference on Computer Vision and Pattern Recognition; 2017; Italy: 2860-2864.

[14] A Miguel, S Beery, E Flores, L Klemesrud, and R Bayrakcismith, "*Finding areas of motion in camera trap images*". IEEE International Conference on Image Processing; 2016; USA: 1334-1338.

[15] JH Giraldo-Zuluaga, A Salazar, A Gomez and A Diaz-Pulido, "*Recognition of Mammal Genera on Camera-Trap Images Using Multi-layer Robust Principal Component Analysis and Mixture Neural Networks*". IEEE 29th

International Conference on Tools with Artificial Intelligence; 2017; USA: 53-60.
[16] L Camacho, R Baquerizo, J Palomino and M Zarzosa, "*Deployment of a Set of Camera Trap Networks for Wildlife Inventory in Western Amazon Rainforest*". IEEE Sensors Journal; 2017, 17(2): 8000-8007.
[17] H Yousif, J Yuan, R. Kays and Z. He "*Fast human-animal detection from highly cluttered camera-trap images using joint background modeling and deep learning classification*". IEEE International Symposium on Circuits and Systems; 2017; USA: 1-4.
[18] EJ Berkenpas., BS Henning., CM Shepard and AJ Turchik, "*The Driftcam: A buoyancy controlled pelagic camera trap*". OCEANS 2013 MTS/IEEE San Diego; 2013; USA: 1-6.
[19] KPK Reddy and R Aravind, "*Segmentation of camera-trap tiger images based on texture and color features*". 2012 National Conference on Communications; 2012; India: 1-5.
[20] U. Bolat, "*Camera trap Kullanım Rehber"i*. T.C. Orman Su İşleri Bakanlığı Doğa Koruma ve Milli Parklar Genel Müdürlüğü, Ankara 2017.
[21] C. Taştimur, H. Yetis, M. Karaköse and E. Akın, "*Rail Defect Detection and Classification with Real Time Image Processing Technique*". International Journal of Computer Science and Software Engineering; 2016, 5(12): 283-290.
[22] C. Taştimur, M. Karaköse and E. Akın, "*A Vision Based Condition Monitoring Approach for Rail Switch and Level Crossing using Hierarchical SVM in Railways*". International Journal of Applied Mathematics, Electronics and Computers; 2016, 4(Special Issue): 319-325.
[23] E. Karakose, M.T. Gencoglu, M. Karakose, I. Aydin and E. Akin, *"A new experimental approach using image processing-based tracking for an efficient fault diagnosis in pantograph–catenary systems".* IEEE Transactions on Industrial Informatics; 2017, 13(2): 635-643.
[24] S. Ozdemir, M. Erol and A. Tokgoz, *"Yaban Hayatını İzlemede Fotokapan Sistemleri*", Lisans Tezi, Fırat Üniversitesi, Elazığ, Türkiye, 2018.
R.Dhanujalakshmi, B.Divya, C.Divya@sandhiya, A.Robertsingh, "*Image Processing Based Fire Detection System using Rasperry Pi System*" SSRG International Journal of Computer Science and Engineering .4(4), 2017.