Survey: Invasion of the Chinese Mitten Crabs: development of a monitoring sensor

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***Abstract*—The Chinese Mitten crab is an invasive species in Flemish rivers and canals. Their migratory and burrowing behavior has caused ecological and economical problems. To counter them, a monitoring sensor is being developed. An implementation has already been described in a previous study. A raspberry pi with a camera was used with a yoloV3 recognition model. This approach was tested in simulation using video's. This paper will try to achieve the same results while minimizing power consumption and testing the setup in the field. To save power the possebility of an underwater wildlife camera using a motion sensor and esp32-cam will be explored. This paper also briefly explores using a more low technologie solution. //TODO add result**

I. Introduction

There is currently no good way of monitoring the movement of the chinese mitten crab. Today they need to be manually caught using traps or catching nets. Then they need to be manually counted. This is not ideal and the purpose of this paper is to automate this process. Some work on this topic has already been done and a decent solution has already been proposed. [1] However, this solution fails to adress the fact that some rivers can be remote and are therefore not as easy to service for example every day. That is why this research will use the same methodology but try to alter the design so that it uses less power. The ultimate goal of this paper is to make a system that can achieve acceptable results but can be left to work on its own for as long as possible. Lowering the overal power consumption of the system is how this research tries to accomplish this goal. While working towards this goal we can not forget the original requirements. For these requirements we refer to table one of section two of the paper by Ruben Joosen and Satish Singh. [1] In section II we briefly discuss the possible use of a low technology alternative building on existing infrastructure. In section III we take a more digital approach building on the work of the previous paper. We will discuss our used materials, ideas and approach here. In section IV we will test our ideas from section III and evaluate them on power consumption and accuracy. Section V is the conclusion.

II. Low technology solution

To effectivly solve a problem we must not be afraid to look in other directions than the most obvious one. That is why this section discusses the use of a low technology solution.

A. Idea

Traps that are currently being used rely on the fact that the crabs are able to verticaly climb on a piece of mesh and are able to move in both water and air. Crabs walking over the river floor cross a concrete ramp and fall into a slit. The only way out of the slit is by following a tube that comes out of the water and ultimatly ends up in the collection box. [2] These traps could be easily modified to automazi the counting of the crabs. We can do this by adding a light source on one side and a light sensor on the other side of the trajectory of the crabs when they fall into the collection box. When the sensor registers that the light has been interupted it can send a signal to a low power microcontroller which keeps track of the count. When automaticly counting the collection box could be removed so that it does not need to be emptied. Then such a system has the possibility to opperate for a very long time without human interferance. In 2020 the traps had caught over one million crabs in two years while only catching two toads. [3] Altough far from every crab gets caught its a system that has proven its worth over the years. So further expanding on this idea by adding the neccessary electronics sounds promising.

1) Problems: Seting up a trap like this is unfortunatly not cheap or easy. During installation the water level should be temporary lowered to make it easier. This is ofcourse not possible everywhere. The weight and size of the components needed can also pose difficulties in some cases. [3] Once installed it is not easy to just relocate the trap. So unfortunattly this solutions fails on the low cost and ease of use requirements.

III. Machine vision solution

A more portable and cheaper solution is the use of a camera and a platform running a machine learning algorithm much like the paper before this. [1] We will reevaluate the hardware and software, focusing on the low power constraint.

A. Hardware

1) Power measurement: All power measurements in this paper were done with the power profiler kit II (ppk2) from nordic semiconductors.

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2) Platform: The original paper used a raspberry pi 4B but in regard to power consumption we have better options. Selecting a platform is always going to be a trade of between consumption and performance but eventually we settled on the esp32-CAM kit. Which is a set containing an esp32, an sd card reader and an OV2640. The esp32 is a fairly low power microcontroller (mcu). An important factor in choosing this board was that there are a lot of examples of people using this board for ml applications on the internet. So it is low power and we know it can handle the load, it also commes with 520 kb ram which in most cases is enough to fit an oke model. The original paper does not mention any power consumption for the raspberry pi 4B. We can find that in idle mode the pi uses around 575 milliwat (mw) [4] which is significatly less than what we measure for the esp32 which we found consumes only an average of 39 ma when running a simple blink program. Another advantage of the esp32 is its ability to go into deep sleep. When in this state we measured an average consumption of only 10 ma.

3) Vision: A big downside of the esp32-CAM kit is that the camera does not have night vission. This can be fixed by manually cutting out its IR filter and adding a few infrared (IR) leds to the project. 850 nanometer (nm) golflengte leds were chosen over 940 nm leds because IR cameras are more sensitive to 850 nm. This leads to better quality pictures. need source

4) Movement detection: To further lower power usage we want to evaluate the effect of incorporating a movement sensor into the system. Because we only need to take a picture and run our recognition model when something is in front of the camera. So in theory in some cases the use of a movement sensor to trigger the rest of the system will be more efficiënt. Since the crabs are cold blodded we opted for a microwave sensor over a passive infrared sensor (pir). We used the Gravity microwave sensor V2 from DFrobot. After desoldering unnessecary leds we measured an average consumption of 47 ma.

B. Software

1) Model: To train the model we used Edge Impuls which is an online platform. Using this platform we can label all our data and quickly train small models for use on the edge. We chose to use Faster Object More Objects (FOMO) as our model. We chose this model over the original YoloV3-tiny because it is more suited to this particular use case. It works well with a fixed camera and objects that are roughly the same size. It is proven to work well on small mcu's. needs source? Instead of detecting bounding boxes it only detects centroids which is fine for our use case.

C. Approach

We combine our hardware and software to create a system that hopes to save power by working like an underwater wildlife camera. Our choice in hardware and software already significantly lowers our power consumption compared to the previous setup. We can try to save more by, instead of constantly running our model on a video stream, taking photos periodicly and run our model on those photos. We will try to use our movement sensor to further bring down the power cost. We will try a few different configurations and evalute them on power consumption.

- The movement sensor is always on and on detectection wakes the esp32 up from deep sleep. The esp32 then takes a picture and runs the inference.
- Every x seconds the mcu wakes up from deep sleep and for y seconds turns on the movement detector. When movement is detected a picture is taken and the inference is run.
- Every x seconds the camera takes a picture and the esp32 runs the inference.

The accuracy of the model will also be evaluated.

IV. Experiments

Experiments go here

V. Conclusion

The conclusion goes here.

References

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