Automated Film Development with Arduino

Project Proposal

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INTRODUCTION

For nearly a century, film photography empowered the average consumer to capture life’s moments at the click of a button. Consumers would take their exposed film to the local lab and pay a nominal fee to develop and see the results of their photography. But, at the turn of the 21st century, digital photography eclipsed the film camera due to its convenience, affordability, and feature set. Film labs shuttered, and analog cameras sold fractions of their original value. However, recently, film has seen a resurge in the past decade, with the price of film stock and used gear rising. The appeal of the vintage aesthetic and the more “purposeful” and tactile experience with analog photography has brought a whole new generation of users and admirers.

The resurgence of film photography, however, has also driven up the cost of photography. Companies such as Kodak have restarted their production of film stocks but at a premium. Developing, because there are few labs, is expensive and timely. Many have turned to at-home DIY solutions. However, this manual process relies on chemical solutions that often have a steep learning curve. To bridge the gap between the analog and digital age, this project proposes a solution to the film development process, which is one step in the craft of analog film photography.

This system aims to automate the at-home film development process. Using an Arduino Nano ESP32 (an Arduino board based on an ESP32 microcontroller), the system will take the sensitive and manual process of film development from the hands of the photographer and will operate the process itself.

Our project seeks to address several key challenges faced by developers, including inconsistent results due to variations in developing times and temperatures, as well as the labor-intensive nature of manual processing. By leveraging the power of Arduino, we aim to automate and standardize the film development process, ensuring consistent and high-quality results with minimal user intervention; hopefully, the user will be able to press “start,” walk away, and come back to professionally developed negatives.

Through this project, we envision empowering photographers of all skill levels to explore the vintage art form of analog film photography with confidence and convenience. Whether it's a seasoned professional looking to streamline their workflow or an aspiring enthusiast eager to delve into the world of film photography without expense, our project promises to enhance the experience of analog film photographers.

To showcase this project, we will demonstrate in real time the development of a roll of film (including a recent newspaper), and show the negative results. Moreover, in the prototyping fair, we intend for participants to expose a whole roll at the beginning of the event and, by the end, see their photos thanks to our automated development process.

Related Works

Several initiatives have been executed to create an automated film development process. Among the relevant projects are ones that are implemented using microcontrollers as well as high-end, expensive solutions to the same problem. These projects and products include the following:

1. **Spinmatic automated film development:** This project combines 3D printing, electronics, programming, and analog photography. The maker designed a 3D-printed spindle to hold the film canisters and have the 3D templates freely available for those looking to build on this innovative concept. They used an Arduino microcontroller and servo motor to control the spinning, added a speaker and display for status updates, and programmed a timer to precisely control the duration and intervals of rotations during development. https://www.instructables.com/Spinmatic-Automated-Film-Development/
2. **DIY Automated Film Developing Machine:** This project is another great example of utilizing the Arduino board to create an automated film development machine. This video shows the proof of concept that we are hoping to achieve. This project utilizes pumps and valves along with the board. The specific pump used in this project is TOPSFLO TG-02BT-12-025 DC FDA micro gear pump self-priming https://www.youtube.com/watch?v=NaCq_mbBP0o

3. **DIY ROTARY FILM PROCESSOR:** This project similar to number 1, also utilizes wheels in order to enable the rotation of the tanks. However, instead of using the water for rotation, they utilize a roller base. They mentioned their choice for not utilizing water for rotation for the following reasons:
    a. Content with developing at room temperature
    b. Saving water
    c. More compact and storable design:

    http://sgwetplate.com/2016/10/diy-rotary-film-processor

4. **Robotic Lab Monkeys:** The creator took a creative DIY approach to automating different parts of the film development process, using simple components like Arduino microcontrollers, servo motors, and modeling clay to build affordable setups for tasks like agitation and rotation. She explored progressively more complex solutions, from a basic robotic "stick agitator" made from spare parts to adapting a commercial rotary film processor, evaluating the trade-offs between cost, complexity, and capability for each method.

    https://www.sheshootsfilm.photography/articles/film-development-automation

5. **DIY Rotary Drum Film Processor:** This project was neat to come across as we had not yet considered leveraging water buoyancy for rotation. The space between the wheels can be adjusted to fit for different tanks. This project approach seems more affordable than previous ideations.

    https://www.youtube.com/watch?v=suQTE3wx_Jk

6. **OpenAutoLab :** This project is a great example of what is possible with using an Arduino to control the process of film development. Some of the parts used in this project are able to be 3D printed and others are relatively affordable. However, the building and implementation appear quite complex.

    https://blog.arduino.cc/2024/01/03/openautolab-lets-you-automatically-develop-photos-at-home/

7. **Monkey Sailor's Photo-Lab:** This project unlike the previous example encapsulates the process into a box-shaped case. It also focuses on agitating the film automatically, and storing the desired time and temperature settings.

    https://mak4ezine.com/projects/monkeysailors-photo-lab-2/

8. **Chromabox-4:** At an expensive $2500 (USD), the Chromabox-4 is a high end solution to the problem of automating film development. It has capacity for up to 4- 6 rolls of film (depending on the size) and has custom controls available. This product is far beyond the scope of what we hope to achieve with our project but is a great example of a premium version for the advanced film photographer or development labs.

    https://www.midtonemachines.com/

9. **Develophead:** Unlike the expensive and all-encompassing products on the market, such as the Chromabox-4, this is a solution that is an addition to the tank cap and aims to automate just the agitation process in film development. The benefit of this work is that it is an open-source solution that uses Arduino and costs less than $10, according to the developer of the solution.

    https://blog.arduino.cc/2018/08/06/develophead-takes-some-of-the-work-out-of-film-photography/

10. **Filmomat:** Even more expensive than the Chromabox-4, the German-made Filmomat retails for €3990 (EUR) and is an automatic film processor for rotational development of up to 4 rolls of 135/120 film, large format film, as well as motion picture films (Super-8 and 16mm). This is an example of the most premium product that could be offered as a solution to automating film development but is out of scope for what we aim to accomplish with this project.

    https://www.filmomat.eu/

Most of the projects leverage Arduino microcontrollers to control motors and timers for automating the rotation and agitation of film tanks. This shows Arduino provides an affordable and customizable way to automate key parts of the process. We can use Arduino with motors and sensors in a similar way.

Several projects use 3D-printed parts or custom-built spindles/wheels to enable the rotation of tanks. We could 3D print custom holders, wheels, and other components to fit our tank size and design constraints.

Some solutions focus just on the agitation process, demonstrating you don't need to automate every step. We should prioritize automating agitation as it's critical and complex. Other steps could be manual if needed to simplify.

Most DIY solutions rely on rotation via servos, small motors, or buoyancy in water rather than complex pumping systems. This is likely sufficient and more affordable than integrating pumps.

Open-source projects provide code and schematics from which to learn. We can reference these to help select our components and develop the programming.

Higher-end commercial products showcase advanced functionality but are expensive and complex. Our goal is an affordable DIY automated solution meeting the basic needs of photographers. We don't need the complexity of commercial machines.

In summary, we can take inspiration from prior DIY Arduino-based projects that used 3D-printed parts and simple motors to automate agitation and rotation. We'll select affordable components, leverage open-source code, and focus first on automating the most critical yet tedious agitation task in development. The goal is a simple, low-cost, automated solution accessible to photography enthusiasts rather than an expensive all-in-one system requiring advanced engineering.

Initial Design

The basic process of film development is as follows:

1. In a dark changing bag, load the film onto the reel with careful precision.
2. Fill the tank with warm water before developing. Remove after submerged.
3. Add developer to film tank, keeping a consistent temperature and gently agitating at intervals for even development.
4. Remove the developer and add lukewarm water to stop development.
5. Add a fixer to make the crystals of the negatives stable.
6. Thoroughly rinse the film to remove any residual chemicals before hanging it to dry in a dust-free environment.
7. Once dry, cut and store the film in protective sleeves or canisters.

We plan to automate this process for our project.

Primary Features

Adding and removing chemicals from the developing tank:

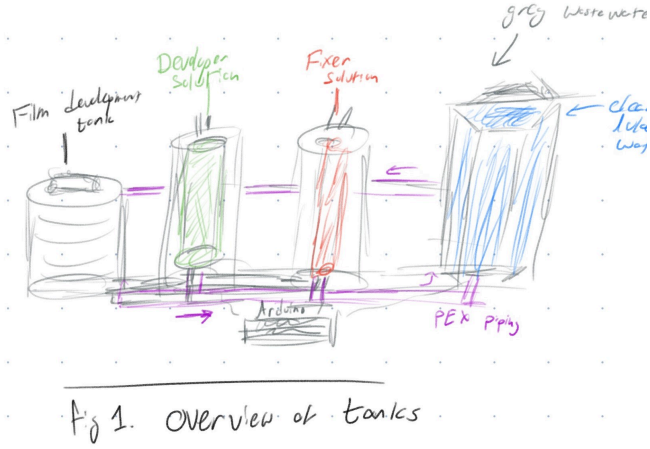

Fig 1. Overview of tanks:

We see the proposed structure of the device. On the left is the developing tank, to which developing solution (green), fixer solution (orange), or clean water (blue) can flow via PEX piping. The remaining solution can be piped to the grey water tank.

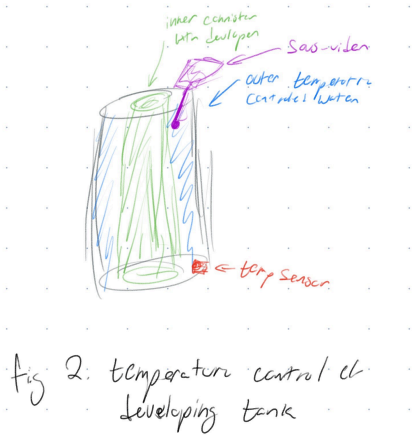

Fig 2 Temperature control of developing tank:

Within the tank, the developing and fixer solution with be submerged in an outer tank of temperature-controlled water. A sous-vide and temperature sensor will provide constant feedback and adjustment to ensure consistent temperature and optimal development.

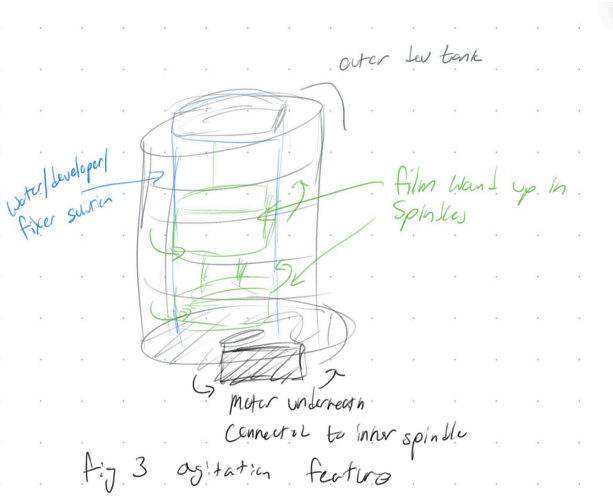

Fig 3. Agitation of film spools:

Agitation of the film negatives is important. Thus, a servo under the tank, directly connected to the spools, will spin them at appropriate times.

Prioritization of Features

As a minimum viable product, we hope to have the basics of film development completed: adding developer, fixer, and water. We hope to improve reliability and results with temperature control and auto-agitation. Beyond this, there are ideas of extraction and scanning. Each of these features is listed and described in the order of highest priority to lowest:

Basic development: The ability to place film spools in the tank, and have the adding/removing of solutions automated. Such that developer, fixer, and water, are added and removed, at the proper times, without user input.

Temperature control: Ability to maintain an optimal temperature for proper film development, using a sous-vide and temperature sensor.

Agitation: Movement of the film spools in the film tank at regular intervals for well-distributed development.

Extraction: Automating extracting the film from the canister onto the film spool, all in darkness, without user input.

Scanning: The scanning of the completed negatives to positive color results. There are alternatives that exist to this process, such as using a digital app on a smartphone that can complete this process with relatively decent results