1 Purpose

Documentation for panoramicam

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2 Panoramicam

The Concept

Panoramicam is a digitally controlled, single-exposure panoramic camera of the slit-scanning type. It is capable of making a continuous exposure on 35mm film of 1080° or more. As the camera pans horizonally, and the image moves across the focal plane, the film is moved through the film gate at the same speed as the image. The result is an image with unique temporal and geometric perspective.

The concept of a scanning-type camera is not new. The Cirkut camera was scanning camera that was produced around 1905. It used large-format roll film and mechanical clockwork to take panoramic images of up to 360 degrees. The large negatives were then contact printed in the darkroom. These cameras are

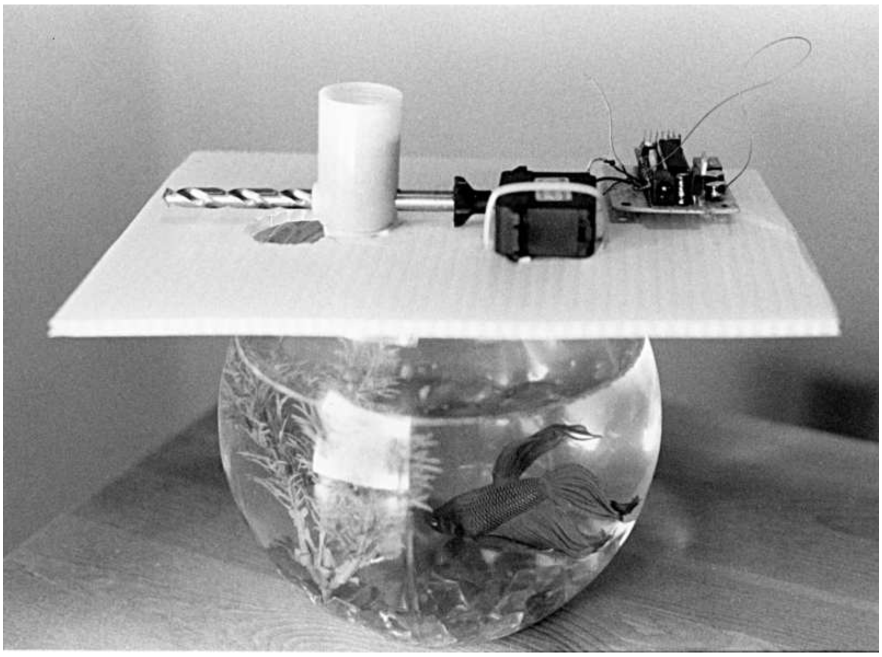

Figure 1: Panoramicam

now rare and expensive. Scanning-type cameras have also been used deliberately to create distorted images for motion picture special effects, such as the "warp effect" from *Star Trek* and the ending bit of *2001: A Space Odyssey.*

Implementation details

The goal of the Panoramicam project was to create a slit-scanning camera for my own use, which fits into my photographic workflow, and which uses currently-available film.

I would have prefered to use larger film, but 120-size roll film would generate contact prints which are small and unimpressive, and enlarging such a negative would be impossible without either a 10x10 enlarger or a specially-built slit-scanning projection printer.

The enlarging requirement led to the use of 35mm film. With 35mm film, a wide-ratio negative can be enlarged using a common 4x5 enlarger. The technical limitations imposed by the small film can be somewhat mitigated by the fact that the camera design allows generous exposure, so fine-grained film can be used at all times.

If digital output is acceptable, the film or prints can easily be scanned using currently existing technology. Of course, this would also be the case for 120-size film, but I am specifically interested in chemical photography, and I require the ability to make optical prints. Where a digital image is acceptable, a common panoramic technique is to stitch multiple files from a digital camera into a panorama — something which is widely done. But the continuous nature of the scanning camera's exposure provides images with a dynamic nature different from images generated from multiple still images.

Figure 2: An early prototype

3 Theoretical Development

The essential requirement of the slit-scan camera is this: the speed at which the film is moved through the film gate must equal the speed at which the image moves across the focal plane. If this synchronization is not maintained, the image will not be sharp. The speed of the image movement doesn't change during the exposure, because the camera rotates with a constant speed for an even exposure. However, we can see that if we pull the film by wrapping it around a spool, the effective diameter of the spool will change as the film winds on. If the turning speed of the spool is kept constant, the speed of the film-pulling will increase as the exposure proceeds. A capstan drive or a "large" takeup

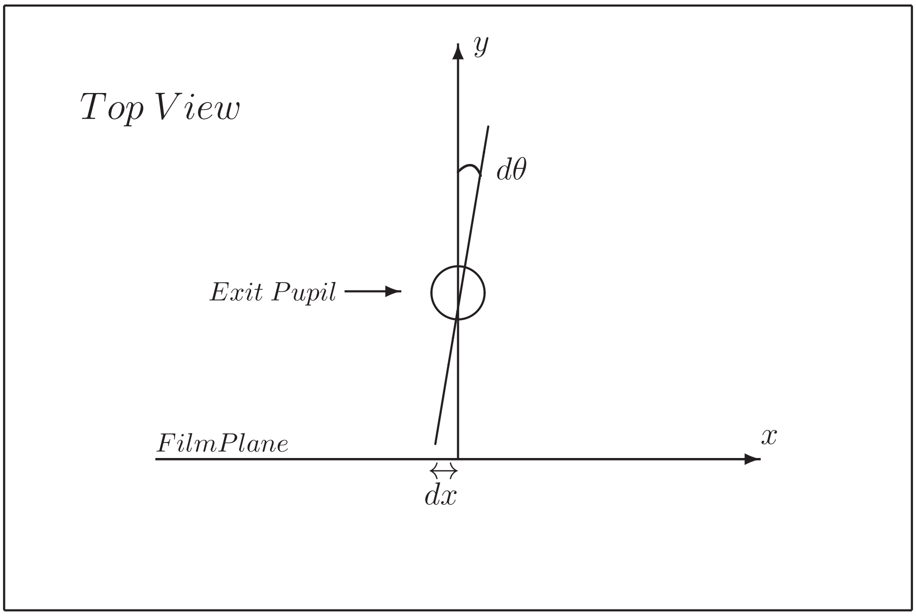

Figure 3: Theta

spool would mitigate this concern. Another option would be to directly sense film speed (somehow) and use servo feedback to maintain the film speed, but since I opted to build Panoramicam from an existing 35mm camera, my best option was to model the film-piling and continuously change the winding speed in an "open-loop" manner in order to keep synchronization lock between the image speed and film speed. This turns out to work quite well.

Referring to figure 3, and considering a small angle, we can see that the image speed, $\dot{x}$, depends on the panning rate, $\dot{\theta}$ and the focal length of the lens,f, expressed thusly:

$$\dot{x} = f \cdot \dot{\theta}$$

Referring to figure 4 we can see that the linear film speed, $\dot{x}$, depends on the turning rate of the takeup spool, $\dot{\phi}$, and the instantaneous diameter of the takeup spool, R, which itself is determined by the film thickness, t, the starting spool diameter, r, and the instantaneous total angle turned by the film spool, ϕ, expressed thusly:

$$\dot{x} = \dot{\phi}\left(r + \frac{t\phi}{2\pi}\right)$$

Thus in operation, the speed of the film winding spool, $\dot{\theta}$, must be maintained as

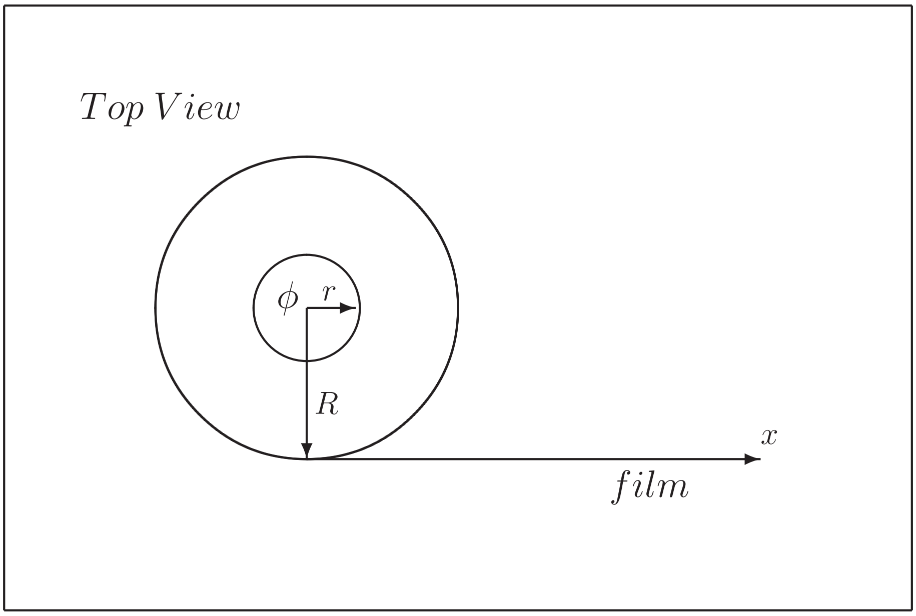

Figure 4: Phi

$$\dot{\phi} = \frac{f\dot{\theta}}{\left(r + \frac{\theta t}{2\pi}\right)}$$

This establishes the 'sync function' needed to implement the programming. Since common microcontrollers lack hardware for performing floating-point math, several simplifications are used in the actual algorithm.

4 Hardware description

The Camera

Panoramicam uses a 35mm camera body as the core. An Olympus OM1 was chosen because it has a mechanical shutter, which allows the shutter to be locked open without draining the camera batteries. Also, the rewind control is located on the front of the camera, which simplifies operation. The designer also has a supply of OM-mount lenses.

The Platform

The camera body is placed on a rotating platform so that the lens nodal point is centered over the pivot point for the platform. A stepper motor is interfaced to the film rewind crank with a M4 screw and coupling made from a 7mm socket. The stepper is quickly removable to allow the film to be changed.

S3	S2	S1	Rotation Period	T, 28mm lens, s	T, 50mm lens, s
0	0	0	8 seconds	1/16	1/30
0	0	1	16 seconds	1/8	1/15
0	1	0	32 seconds	1/4	1/8
0	1	1	64 seconds	1/2	1/4
1	0	0	10 minutes	6	3
1	0	1	20 minutes	12	6
1	1	0	1 hour	60	30
1	1	1	4 hours	120	60

Figure 5: Exposure-DIP switch table

The Base

The base is formed from aluminum plate. The bearing assembly is built from laminated plastic and the bearings are bronze oillite type.

The Motion Control hardware

The film is wound by a bipolar stepper motor. An Allegro microstepping driver board is used to control the stepper, and an AVR ATMEGA168 is used with a Boarduino project board for control. A daughter board provides DIP switches and pushbuttons for human interface.

The base is turned by a unipolar stepper motor interfaced to the platform through a neoprene timing belt at a gear reduction ratio of 6:1, giving 1200 full steps per platform revolution. The stepper is driven by a simple 4-transistor driver board, which is in turn controlled by another AVR microcontroller. To provide smooth motion, the motor is driven as a high-pole-count AC synchronous motor by sine waves synthesized by the microcontroller's PWM output. A daughter board provides buttons and DIP switches for human interface.

5 Operating Instructions

Initial Setup

1. Choose platform rotation period and enter the DIP switch settings on the base daughter board. Consult figure 5 for help choosing exposure.

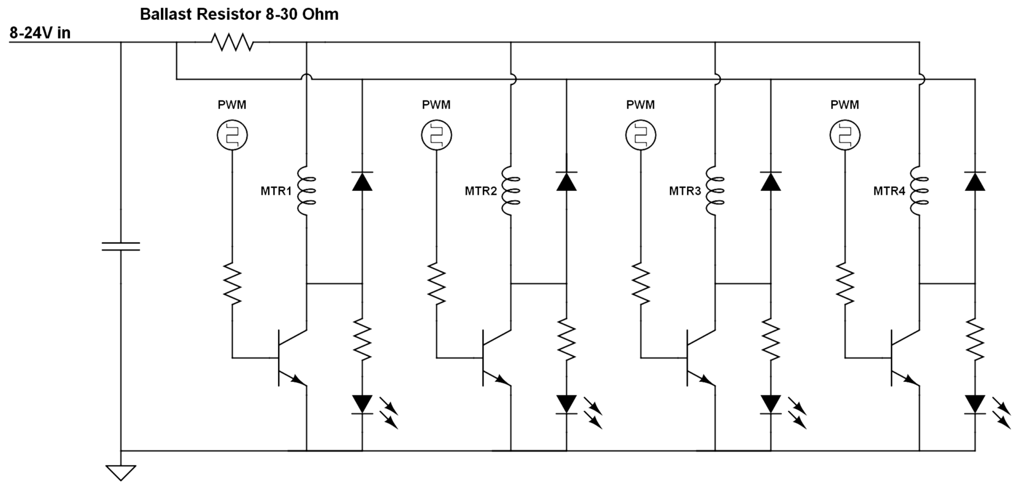

Figure 6: Stepper Daughter Board Schematic

2. Enter the same settings on the platform daughter board. If these DIP switch settings don't match between the platform and the base, interesting psychedelic smearing will occur in the images.
3. Set switch 4 according to the lens installed. See the previous note on psychedelic smearing.
4. Power up both the platform and the base. Check the green LEDs and make sure the microcontrollers are powered up. The red LEDs will blink to confirm the speed settings chosen.
5. Using the manual input buttons, rotate the platform to the orientation in which you would like to begin exposure.

Load the film

1. Determine if there is film in the camera already. There is no good way to determine this, so take notes. You could always try rewinding it to be safe.
2. Remove the film motor and load the film in the usual way.
3. Close the back, fit the lens cap and fire the entire roll using the motor drive.
4. Fit the film motor back on. Using the manual input buttons, turn the spool drive 1/2 turn to take up film slack.

Make The Exposure

1. To begin exposure, press the start buttons on both the platform and the base at the same time (within 1 second).

2. Exposure will automatically stop. To stop exposure early, reset the controllers or yank the power cords.

6 Software Functional Spec

Software Requirements

Errors, Faults and Programmability

Errors will be indicated with a blinkenled for diagnostics purposes. A table will be added to this document detailing the errors.

Development

The sofware is written for the AVR ATMEGA microcontrollers using the GNU C compiler for the AVR (avr-gcc). The vi text editor will be used for development and git used for revision control.

END OF DATA