1 Purpose

Documentation for panoramicam

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2 References

panoramicalcs.ods	Documention spreadsheet
Allegro A4988	datasheet

Figure 1: Panoramicam

3 Definitions

theta The angle of the platform, referenced to the start position

phi The angle of the film spool, referenced from the start position

Nodal length The mechanical focal length of the lens (distinct from optical focal length)

base The stationary part of panoramicam, which attaches to the tripod

platform The rotationary part of panoramicam, which holds the camera

4 Panoramicam

The slit-scan camera concept

A slit-scan camera is a type of panoramic camera that makes a continuous exposure while panning horizontally. As the image moves across the focal plane, the film is moved through the gate at the same speed as the image. The result is a panoramic image of 360 degrees or more with a unique perspective. To reduce smearing from perspective distortion and to reduce exposure, a mask is typically placed in the film gate, blocking the image but for a thin vertical slot.

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 degree. The large negatives were then contact printed in the darkroom. These cameras are now rare and expensive, and if film is still available, it will not be for long.

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.

In designing Panoramicam, I first considered using 120 film, which is essentially a miniature version of the large-format film used by the Cirkut camera, and still widely available. The problem with using 120 film is that it will generate contact prints which are quite small and thus unimpressive. Enlarging the negatives would be impossible without either a 10x10 enlarger or building a special slit-scanning projection printer.

Photographic negatives can digitally scanned and the image printed digitally. This would allow use of 120 film; however I am specifically interested in chemical photography. I typically work with physical materials, and have little interest in digital imaging. If digital output was acceptable, it may be preferable to use a digital camera in the first place, and simply stitch together images–something which is widely done. It is still true however that the continuous nature of the slit-scan exposure provides images with a dynamic nature different from images generated from multiple still images.

The ability to make optical prints required use of 35mm film. With 35mm film, a wide-ratio negative can be enlarged using a common 4x5 enlarger. The use of such small film imposes some technical limitations, but those limitations are somewhat mitigated by the fact that the camera design allows generous exposure, so that fine-grained film can be used at all times. If digital output is desired, the film can easily be scanned using currently existing technology.

Figure 2: Panoramicam II

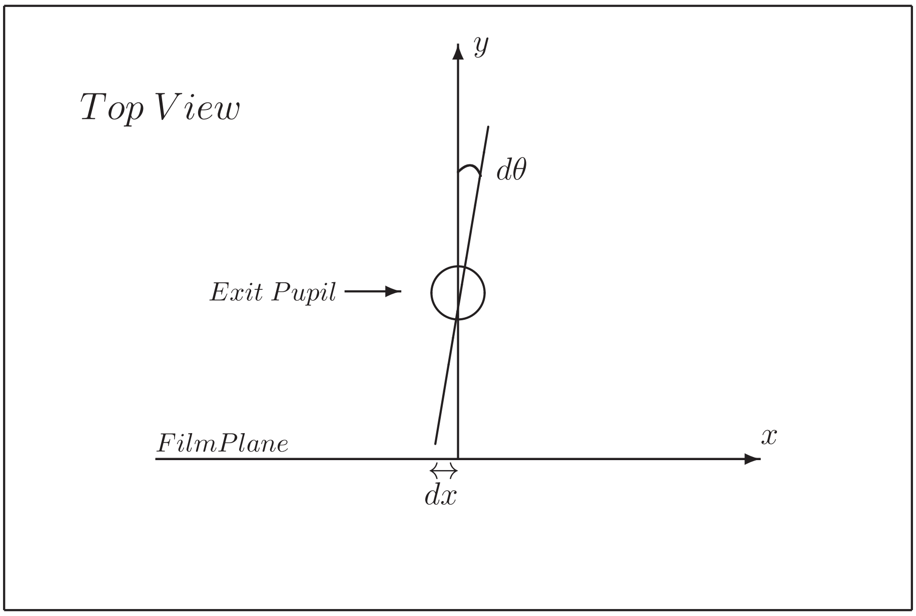

Figure 3: Theta

5 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.

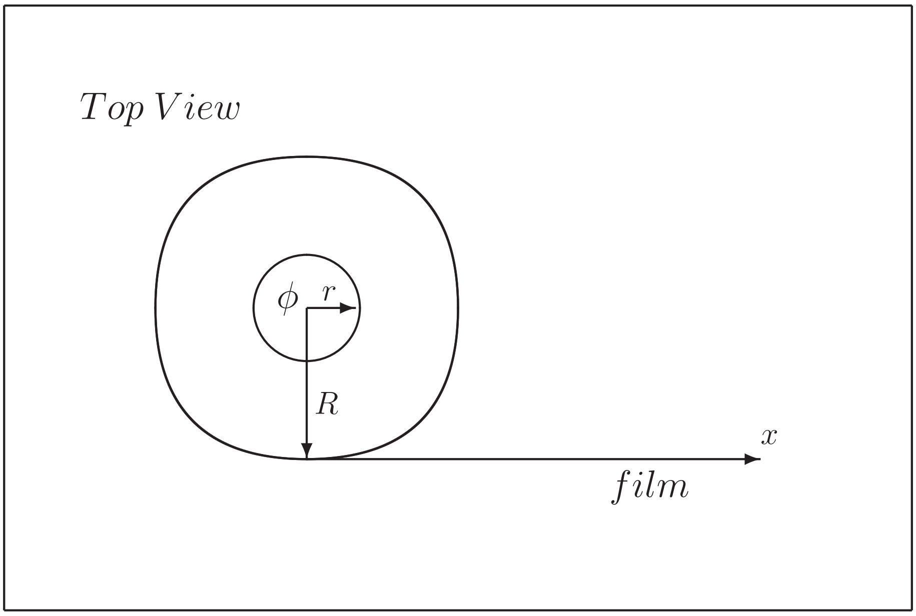

Figure 4: Phi

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 angular 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:

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

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

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

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

6 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. A stepper motor is interfaced to the film rewind crank with a M4 screw and coupling made from a 7mm socket. The stepper is hinged to allow the film to be changed.

The Base

The base is formed from aluminum plate. The bearing assembly is made from a harmonic drive assembly.

The Motion Control hardware

At the platform, the film is wound by a bipolar stepper motor. An Allegro microstepping driver board is used to control the stepper, and an AVR AT-

MEGA168 is used with a Boarduino project board for control. A daughter board provides DIP switches and pushbuttons for human interface.

At the base, a unipolar stepper motor is interfaced directly to the platform. The stepper is driven by a 4-transistor, current-limiting driver board, which is in turn controlled by an AVR ATMEGA168 microcontroller on a Boarduino. To provide smooth motion, the motor is driven with sine-wave control synthesized by PWM output. A daughter board provides buttons and DIP switches for human interface.

7 Operating Instructions

Initial Setup

1. Ensuring the batteries are charged, plug both power cords in. Check the green LEDs and make sure the microcontrollers are powered up.

2. Choose platform rotation period and enter the DIP switch settings on the base daughter board. Consult table **??** for help choosing exposure.

3. 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.

4. Set switch 4 according to the lens installed. See the previous note on psychedelic smearing.

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. Flip the film motor up and unlatch the back by pulling up on the spool drive. 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. Flip the film motor back down and ensure it fits on the spool drive. Using the motor drive 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. To stop the exposure, or to abort, yank the power cords.

8 Software Functional Spec

The theoretical development section above serves as the fundamental description of the camera operation. In implementing the software, concessions have to be made due to the computational limitations of 8-bit microcontrollers, which have no floating-point unit and operate with limited clock speed and memory. In practice, all the linear variables are collapsed to single quantities which are application-specific and correspond directly to the timer registers of the microcontroller, and the nonlinear elements are implemented by approximation.

Basic Software Function

Base

Drive the platform smoothly at a variety of speeds. Provide a user interface that allows different speeds to be chosen and allow the user to pre-position the platform.

Platform

Drive the film motor smoothly at precisely the right speed to capture sharp images. Vary the speed of the film spood to compensate for increased diameter as the film winds on. Keep track of the amount of film wound on, to allow multiple exposures on the same roll. Provide a human interface that allows different speeds to be chosen and the lens to be specified. Allow the user to manually control the motor for setup.

Software Requirements

Inputs and Outputs

Human Interface

The software will provide a user interface that allows either motor to be manually controlled for camera setup. The user will be able to select the operation speed through DIP switches. The user will be able to initiate pictionation sequence.

Input	Function	Arduino pin	AVR PORT pin
Left	Rotate Left	1	B1
Right	Rotate Right	1	B1
Start	Start Pictionation	1	B1
DIP 0	Speed Select	1	B1
DIP 1	Speed Select	1	B1
DIP 2	Speed Select	1	B1
DIP 3	Speed Select	1	B1
DIP 4	Lens Selector	1	B1

Figure 6: Platform Inputs

Output	Function	Arduino pin	AVR PORT pin
Step	Step Motor	1	B1
Dir	Set Motor Direction	1	B1
LED	Blinkenled	1	B1

Figure 7: Platform Outputs

Motor Control

The film motor will be controlled using step, dir interface described in the Allego datasheet (listed in references).

The platform motor will be driven directly using the 4-wire unipolar stepper motor interface from the driver board. A sine-wave drive will be implemented in software, using the PWM capability of the AVR ATMEGA168.

Errors, Faults and Programmability

Errors will be indicated with a blinkenled for diagnostics purposes.

Development

The programs will be 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.

Input	Function	Arduino pin	AVR PORT pin
Left	Rotate Left	1	B1
Right	Rotate Right	1	B1
Start	Start Pictionation	1	B1
DIP 0	Speed Select	1	B1
DIP 1	Speed Select	1	B1
DIP 2	Speed Select	1	B1
DIP 3	Speed Select	1	B1

Figure 8: Base Inputs

Output	Function	Arduino pin	AVR PORT pin
Motor 1	Step Motor	1	B1
Motor 2	Step Motor	1	B1
Motor 3	Step Motor	1	B1
Motor 4	Step Motor	1	B1
LED	Blinkenled	1	B1

Figure 9: Base Outputs

9 Example Source code

The source code shown here is for example only; it is provided as 'pseudo-code' for the reader and does not necessarily reflect the current/latest version.

platform example code

base example code

END OF DATA