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Senior Project
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Analysis of Senior Project Design - Robotic Book Scanner

Summary of Functional Requirements:
We created a proof-of-concept robotic book scanner that can automatically turn pages, take pictures, and compile them into a PDF of the book, with minimal human intervention

Primary Constraints:
We were limited in that we aimed for our design to be easily constructible from just the plans and raw materials and electronic components, as well as cost-efficient, in the same way 3D printers sharply grew in popularity a few years ago. Also, the need for full automation necessitated careful selection and adjustment of robotic components and routines.

Economics:
- Original estimated cost: $400
- Final cost: $283.33
- Bill of materials:

Components	**Cost/Unit**	**Units**	**Supplier**
Raspberry Pi Ultimate Camera Kit (includes board, case, SD card, Raspberry Pi 5MP Camera Board, WiFi card, power supply, and GPIO breakout board)	$102.99	1	Amazon
16-Channel 12-bit PWM/Servo Driver - I2C Interface	$19.20	1	Adafruit
12V Vacuum Pump	$14.95	1	Sparkfun
Generic High Torque Servo (Standard Size)	$12.95	2	Sparkfun
Standard ATX Compatible Power Supply (no more than 200W needed)	$25.00	1	(Salvage)
12” Fluorescent Closet Light	$20.99	1	Rite Aid
Power Strip	$10.00	1	(Salvage)
Wood and Nails	$35.82	1	Home Depot

Vacuum Tubing	$4.68	1	Home Depot
Balloons	$1.99	1	Food 4 Less
Blackout curtains	$11.04	1	Target
Thumbtacks	$1.99	1	(Salvage)
Curtain Rod	$1.49	1	Target
Binder Clips	$4.29	1	Staples
Box (for electronics housing)	$3.00	1	Staples
	$283.33		

- Additional equipment costs, along with shipping and surplus components, raised the total budget to $424.20.
- Original estimated development time: one quarter (~11 weeks).
- Actual development time: one quarter (~11 weeks).

If manufactured on a commercial basis:

-- By nature, our design was intended for hobbyists and tinkerers rather than for commercial production. However, we will attempt to very loosely estimate the following metrics.

- Estimated number of devices to be sold per year: 100.
- Estimated manufacturing cost for each device: $250.00
- Estimated purchase price for each device: $300.00
- Estimated profit per year: $5000.00
- Estimated cost for user to operate device, per unit time: $1 / month (only cost is power consumption.)

Environmental:

While the device takes the usual environmental toll associated with electronics manufacturing, adoption of the device and similar systems could help shift society away from relying on paper and books to store written information, thus saving trees.

Manufacturability:

The device is about as mechanically and electrically complicated as a 3D printer, and can be expected

to have a similar manufacturing difficulty.

Sustainability:

- Issues and challenges associated with maintaining the completed device or system: Because the system is designed using modular, standardized, and easily substitutable components, maintaining the device should be about as easy as maintaining a desktop PC.
- How the project impacts the sustainable use of resources: Along with helping to usher in more of a digital age, the device is meant to be maintainable, rather than disposable, thus making very efficient use of components and other resources.
- Upgrades that would improve the design of the project: a taller housing, more robust servos, a more modular mounting system, and a higher-resolution camera with better optics.

Ethical:

This device raises the same ethical and legal complications as VHS recorders raised a few decades ago, where individuals might use the device for purposes other than digitizing a personal collection and, say, scan a bunch of books from the library. If this becomes widespread, the solution will probably be similar to that of the VHS-recording phenomenon: publishers will be forced into the 21st century.

Health and Safety:

The device does not impose significant health or safety risks unless a user tapes needles to the moving parts and attempts to make very close observations of the machinery.

Social and Political:

See “Ethical.”

Development:

To complete this project, we learned the ins and outs of a new prototyping platform, the Raspberry Pi, as well as the basics of the Python programming language, and gained familiarity with some Unix-based command-line image-processing utilities. We also gleaned some experience with designing our own mechanical parts, experience which is hard to come by as a computer engineer. Also, in the process of constructing the project, we also gained some insights into how servos and stepper motors work.