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# AUTOMATION TEAM RESEARCH REVIEW

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## Abstract

*The automation team has already made the majority of the decisions it needs to make through research and some experimentation. This is a summary of progress, research, and decisions made... annnd.. i'll fill this in as i get to it.*



## 1 Introduction

Sustainability comes in many forms, some easier than others. In most instances, people want to be sustainable, they just also don't want to be inconvenienced. It is the automation team's goal to provide sustainability in a feasible fashion by providing it "cloaked" in convenience through HyveOS.

HyveOS is a software that implements a platform to receive and send data from a house. Data is collected by cameras and microphones placed in public rooms, to which the occupants can issue commands, and received through already owned phones or speakers in the house.

The primary goals for HyveOS are:

*Safety* making houses capable of detecting dangers such as a burglary or an occupant falling down and not getting back up

*Cooperativity* allowing houses to balance each other's energy loads and resources

*Sustainability* letting neighbours to connect with each other and share their own resources, such as tools and food, more easily (and with encouragement from their houses)

*Hands-Free Operation* enabling people to connect fluently to the world of data around them through motion tracking systems more accurate than Microsoft's Kinect

*Community* gently encouraging neighbours to make connections and share with each other

### 1.1 Decisions Made

The decisions described in Table ?? have already been made to differing degrees of certainty.

### 1.2 Requested Feedback

In our case most of the technological decisions have been fairly firmly made. We were able to do this through extensive research and with the knowledge that what we do can be done fairly independently of the other Solar Decathlon teams.

What feedback we do request is where you see automation fitting in with your part of the house. Also I would like to know whether or not you think HyveOS should increase or decrease the scope of its goals or if you think our goals are misguided.

Aspect	Decision	Firmness (0-5)
Satellites Hardware	Raspberry Pi	5
Server Hardware	Custom PC Rig	4
Automation Satellites	Arduino	2
Satellite Operating System	Ubuntu Server	4
Satellite Peripherals	Audio, Visual	2
Primary Interface	Website (with mobile)	4
Primary Language	NodeJS	4
Analytical Language	Python	4

**Table 1:** A tabular description of some of the decisions already made.

## 2 Background

## 3 Servers and Satellites

## 4 The Internet of Things

## 5 The DIY Hardware Movements

## 6 Research

### 6.1 Hardware

Most of hardware concern comes down to Arduino vs Raspberry Pi vs TI Launchpad vs Beaglebone, some of which are depicted in Figure 2. For now, TI Launchpad and Beaglebone will be discounted, though the TI Launchpad is perhaps interesting in that it has the backing of a very large company and is desperate to gain market share.

This distinction is more made at what Hyvdev aims to do. The following quote from James Bruce clarifies the intended purposes of each of these machines.

The Arduino runs the Arduino firmware, a basic bit of core software which allows it to communicate with a computer over USB and gives access to all the features. You generally wouldn't replace this firmware, but it is possible. Once your application has been loaded, you can just plug it in anywhere and it'll start working immediately, you don't need to reboot, plug in a keyboard, or choose an application to run. It does the one job it's been programmed to do, and it does it immediately.

The Raspberry Pi on the other is a complete, functional, mini-computer. It requires an operating system - the first thing you need to choose that will dramatically affect your experience - and has all the bits and pieces you might expect a full computer to have (just in a smaller scale). Storage is provided from a micro-SD card, while built-in Ethernet allows for networking (you can get

networking on Arduino too, but it requires an add-on "shield").

If the Arduino is chosen, then the team chooses its focus is more on typical home automation, such as controlling windows and doors and doing basic home monitoring; alternatively, the Raspberry Pi signifies a much more involved automation process.

The Raspberry Pi was chosen to empower the team to provide a full automation experience, attempting to make the "smart home." As it turns out, a few other groups are also attempting to make the smart home, Nest not the least of them. It is thus our job to also distinguish ourselves from these competitors.

But really, why choose? We can use both, using the Arduino (or TI Launchpad) to control much of the typical home automation and the Raspberry Pi for controlling satellites.

#### 6.1.1 Arduino

The Arduino is a single-board microcontroller that is generally described as perfect for electronics projects. The board has exposed I/O pins for use by other circuits or sensors. A simple example of input and output control that the Arduino can do is translating input from a sensor, such as key presses, to outputs, such as a musical note as long as the keyboard and speakers are attached. Arduino can be programmed from a regular computer, connected via a USB port, which acts also a power source.

Some of the main advantages of using Arduino is both its hardware and software are open source and the Arduino software runs on Windows, Mac and Linux, so it can be programmed from almost any operating system. The Arduino community is actively developing and adding to the programming libraries. It is generally considered most suitable for rapid prototyping in

**Figure 1:** Images taken by the RPi Camera Module (Auto WB, ISO 1600). From left to right : Normal lens, Wide Angle lens, Fisheye lens.



research applications, not for industrial scale usage<sup>1</sup>.

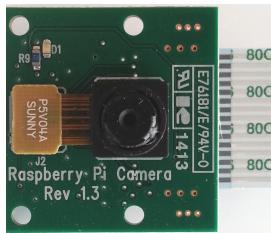
The simpler programming environment of Arduino can be seen both as an advantage and disadvantage. It is a lower barrier of entry for non-electrical engineers to program but it does this by adding one layer of abstraction on top of C, which means you don't have control over every bit and byte of the less abstracted controllers. It is also impossible to fully customize the board as it doesn't allow one to hand-solder components (which at this level, we shouldn't even be considering) Using the Arduino language decreases the portability of the code (not the hardware), so you'd be stuck with Arduino hardware.

Overall, the Arduino board is very flexible with low barrier of entry for those just getting into hardware hacking and lots of examples online. Though it'd be good to keep in mind that Arduinos are good for small projects and prototyping (i.e. trying things out and experimenting). As the teams advances and becoming more familiar with microcontrollers and requiring specialized function, the Arduino may not be suitable.

### 6.1.2 Raspberry Pi

#### 6.1.3 RPi Camera module

The Raspberry Pi Camera Module is an addon for the RPi computer. It is similar to a smart phone camera, with resolution of 5MP. The module connected to the Pi via the dedicated CSI connector on the board.



#### Technical Specs :

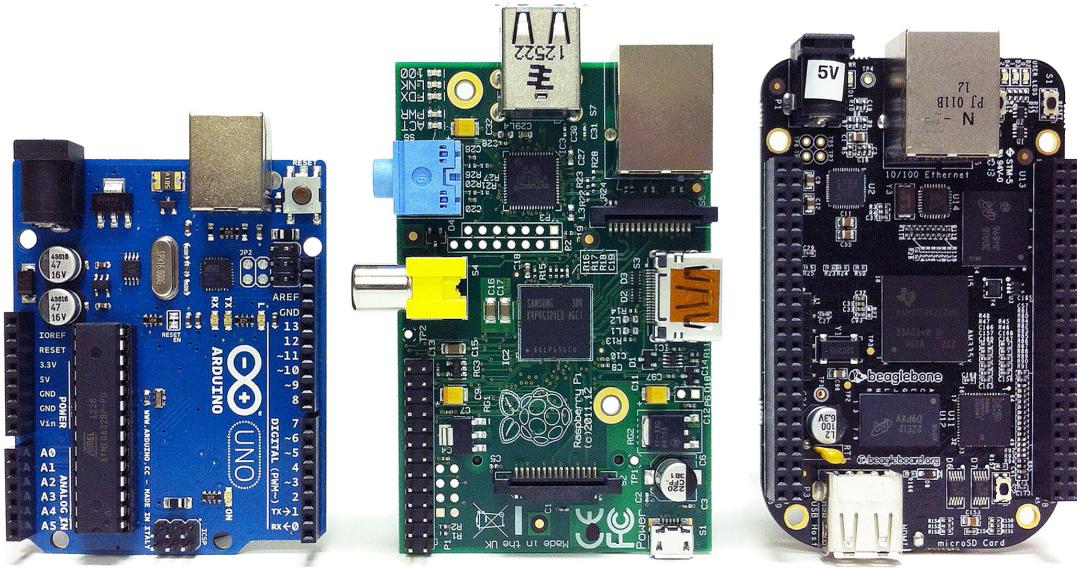
- Sensor type: OmniVision OV5647[4]
- Color CMOS QSXGA (5-megapixel)
- Pixel Count: 2592 x 1944
- Lens: f=3.6 mm, f/2.9
- Angle of View: 54 x 41 degrees
- Field of View: 2.0 x 1.33 m at 2 m
- Full-frame SLR lens equivalent: 35 mm
- Fixed Focus: 1 m to infinity
- Video: 1080p at 30 fps with codec H.264 (AVC)
- Up to 90 fps Video at VGA
- Board size: 25 x 24 mm (not including flex cable)

As seen from the specs, the FOV of the camera module is quite narrow. However, it is possible to use additional macro/wide/tele adaptor lenses. Two solutions are possible : replace the lens completely (risky, but higher image quality) or use a lens designed for smart phone and attach it in front of the module (safe, some quality loss). The use of a wide angle lens is crucial if we want to use it as a home surveillance tool. Focus is also adjustable, but requires some hacking.

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<sup>1</sup>On a slightly subjective note, while some seem to think the Arduino is inappropriate for industrial use, it is not because the Arduino is incapable in any way. This is because the Arduino lacks some certifications and does not have an industry certified training program for its use, so one cannot find engineers "qualified" to use an Arduino. Basically, there is no company supporting it from behind supporting the ecosystem of closed systems where everyone gets a piece of the pie, and because managers and human resources are frequently cowards who would prefer their company passes on blame whenever possible to other companies for hardware failures. The "Programmable logic controller" has this market largely under wrap, with a few other big companies dominating the field. It's a wasteful, cowardly, ridiculous situation, but it is what people will do to successfully dilute blame. For a company to use the Arduino, they would have to accept full responsibility for any hardware issues and would also take it upon themselves to ensure they can find engineers who know how to work with the platform, a list that is apparently too frightening for large companies to bother with so they instead endure the steep costs of deeply entrenched solutions.  
*Calem*

**Figure 2:** An Arduino, Raspberry Pi, and Beaglebone from left to right, demonstrating their relative size. Their absolute size should be inferred by the size of their ports.



The camera has a very good ISO range from 100 up to 1600. High ISO allows the camera to properly expose for low light conditions.

The module is supported out of the box by the Raspbian OS and offers both still image capture, called RaspiStill (up to 2592 x 1900) and video capture called RaspiVid. There are several different modes for video capture, ranging from 640 x 480 at 90FPS to full FOV capture (2592 x 1900 at 15FPS). There are loads of options for each program which gives us a high cus-

tomization factor. "Motion" can be enabled through some 3rd party software. Motion is a motion detection program which is useful if we decides to use this as a surveillance tool.

3rd party software allows the camera to output to openCV which will allow for face recognition/tracking.

The camera comes in 2 model, with or without the IR filter. Cameras without the IR filter have better night vision but suffers from poor color rendering (similar to an infrared security camera).

## 6.2 Software

It is in the software that Hyve is distinguishable. First, let's look at the competitors.

*Nest* is a home automation company that designs and manufactures sensor-driven, Wi-Fi-enabled, self-learning, programmable thermostats and smoke detectors.

*Insteon* is a home automation networking technology that enables light switches, lights, thermostats, motion sensors, and other devices to interoperate through power lines, radio frequency (RF) communications, or both.

*Pointgrab* aims to control all household appliances with natural gestures. Pretty damn cool, but not exactly competing with us yet.

*Revolv* \$299 device that connects existing smart devices, unifying them to make a full smart home.

Nest gets a lot of hype, but is underwhelming from a home automation perspective. It is likely that they will make an aggressive shift into home automation since their purchase by Google.

There are some other competitors, but most follow this tune. It is thus not difficult to see where Hyve can differ.

These other approaches are largely cautious, timid, and realistic. Hyve is a student group, part of the Solar Decathlon competition. We do not need to be realistic at first. We do not need to be cautious. Fortunately, it is the sign of many great adventures (and successful companies) to not be overly concerned about what is considered normal today and instead be prepared for what is normal in the future.

This brings us to Hyve's primary endeavour, which is behaviour modification and true integration of technology and home life, but this topic is saved for the conclusion.

## 6.3 Available Software

This is the most important section of the paper! Here is what's already out there. More importantly, this is what is available to use.

### 6.3.1 WiTrack: Through-wall 3D Tracking Using Body Radio Reflections

A technology from CSAIL at MIT.

WiTrack is a device that tracks the 3D motion of a user from the radio signals reflected off her body. It works even if the person is occluded from the WiTrack device or in a different room. WiTrack does not require the user to carry any wireless device, yet its accuracy exceeds current RF localization systems, which require the user to hold a transceiver. It transmits wireless signals whose power is 100 times smaller than Wi-Fi and 1000 times smaller than cellphone transmissions.

WiTrack localizes the center of a human body to within 10 to 13 cm in the x and y dimensions (about the size of an adult hand), and 21 cm in the z dimension. It also provides coarse tracking of body parts, identifying the direction of a pointing hand with a median of 11.2 degrees. It can also detect falls with 96.9% accuracy. WiTrack can be incorporated into consumer electronics and has a wide set of applications.

The paper for the technology is available [here](#).

### 6.3.2 Wit Speech

Wit speech is one of several online APIs for voice recognition. It's a very attractive package, though perhaps not as good as Nuance's offerings yet. In any case, they provide an excellent description of their service:

Wit.AI enables developers to add a natural language interface to their app or device in minutes. It's faster and more accurate than Siri, and requires no upfront investment, expertise, or training dataset.

It's very simple, really, and very powerful since their AI is constantly improving with hundreds of users.

### 6.3.3 Jasper: Control Anything with Your Voice, Connected to Raspberry-Pi

Jasper is an existing open source platform for developing fully voice controlled applications. Fortunately, it is already designed for the Raspberry Pi, and it is supposed to be very easy to set up on a single Raspberry Pi.

### 6.3.4 SpaceBrew

This is part technology and part resource.

Spacebrew is an open, dynamically routable software toolkit for choreographing interactive spaces. Or, in other words,

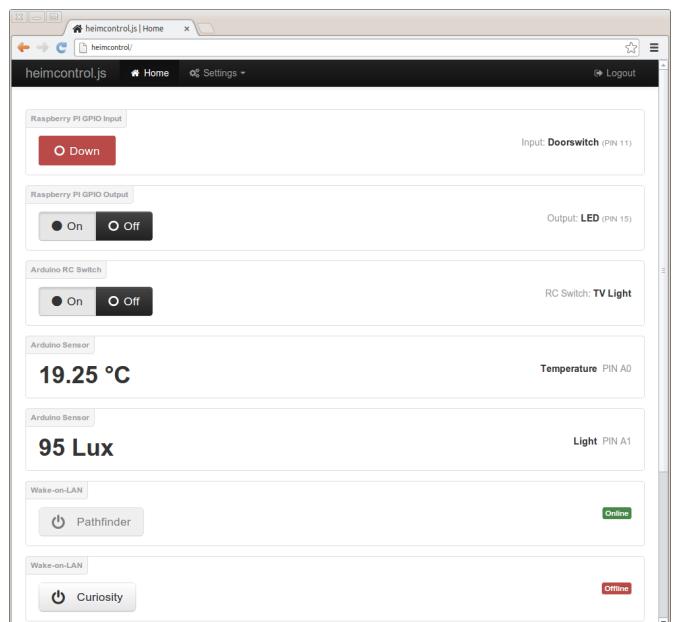
a simple way to connect interactive things to one another. Every element you hook up to the system is identified as either a subscriber (reading data in) or a publisher (pushing data out). Data is in one of three standardized formats: a boolean (true/false), a number range (0-1023) or a string (text). Once these elements are set up, you can use a web based visual switchboard to connect or disconnect publishers and subscribers to each other.

### 6.3.5 HeimControlJS

An existing Home Automation suite with Raspberry Pi and Arduino with a control interface. Hell, it's so much like what we planned on doing it could practically be the result.

I'm seriously considering HyveOS being an expansion on this project and then using the extra time we save to rewrite the entire codebase once with the experience we gain from the first write.

This only covers home automation, and does not include more advanced features of HyveOS.



### 6.3.6 Quake

Not really a resource but you can play Quake on a Raspberry Pi. Damned cool.

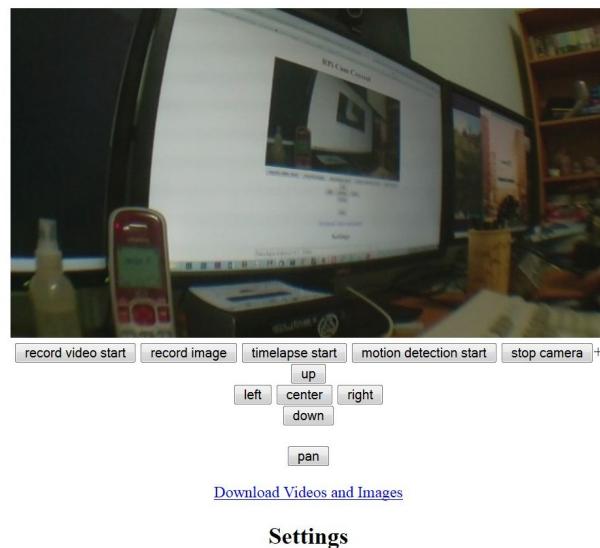
### 6.3.7 RPi Cam Web Interface

This program allows you to stream a live feed from the RPi Camera module( or USB webcam ) to a webpage (hosted by the Pi) at a respectable FPS (around 15) . The feed can be accessed by any web browser. The program also allows high-defintion video recording, motion detection and image capturing. This program can be used for home surveillance purposes. There is currently a prototype built complete with web controlled servos which allows for tilt and pan movements.

**Figure 3: RPi Camera Web Interface Prototype.**



**RPI Cam Control**



## 7 Strategy

### 7.1 Behaviour Modification and Working Toward a Better Society

#### 7.2 title

## 8 Cost Analysis

### 8.1 Raspberry Pi Satellites

### 8.2 Server

### 8.3 Arduino Automation

## 9 Conclusion

Hyve's primary endeavour is behaviour modification and a bolder marriage of technology and the home. It

is through true integration of and comfort with technology that communities can become closer together.

Hyve is designed to both protect the individual, his property, his person, and his privacy, and also to help connect him to his neighbours. While I expand this paper, this will be further detailed.