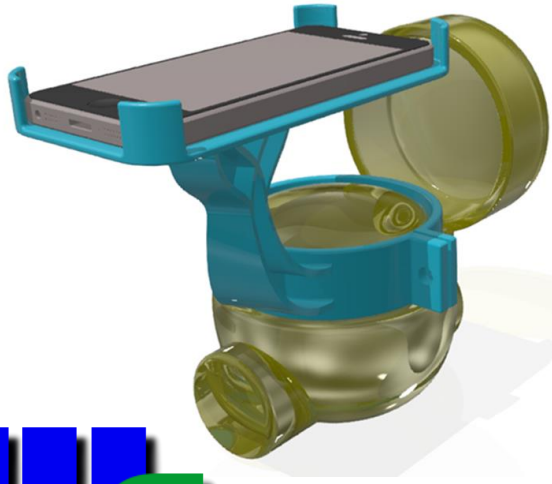

WATER EYES

Using water weyesly

Business Plan

Team 7

- Alexander Wilson
- Hao Wu
- James Sandrolini
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Contents

Business opportunity

Many dwellings have slow water leaks that remain undetected. The result can be damage to the structure and many gallons of water wasted. Utility companies provide the information of amount of water consumed at the end of a monthly cycle and charge the customers accordingly. However, most customers never view the meter and have no reliable means of tracking water usage in real-time.

To solve this, we have created an add-on item for the existing water meter that is both accurate and economical. The solution reads the water meter digits using a repurposed mobile device and relays the information to the user's mobile device. The result is a product that can aid the user in tracking water consumption and detecting leaks in real-time.

The device has the potential to save the user both water and hard earned money. Current solutions in the market are either expensive or inaccurate. There is a pressing need of a low cost but high accuracy solution in the market.

The product offered by our company is composed of two parts. The first part is a service offered at a monthly cost to the consumer. The service consists of a browser application that is run on a retired smartphone supplied by the consumer. The browser application (client side) is used to take photos of a utility company supplied analog water meter (legacy water meter). The photos are sent to a server containing an optical character recognition (OCR) algorithm based on neural network machine learning. The OCR algorithm interprets the digits in the photo and records water usage over time. Included in the monthly cost of the service is an app which would display the water usage statistics in an easy to interpret user interface.

The second component of the business, is to offer the consumer a means by which to mount the retired smart phone to the legacy water meter. There are several manufacturers of water meters, which all come in unique shapes and sizes. Our company intends to supply a 3D printing and design service to meet the needs of the wide variety of water meters and mobile phones. The service is aimed to provide a quality print that the consumer may not be able to achieve without the help of our company. The service will be offered for a fixed price per mount.

The largest design gap of existing offerings is the cost of these devices. They can cost over $600, which is very expensive for an internet of things device for the home. Also, these products require a power outlet, which may not be available at the dwelling where the installation takes place.

Another issue with these devices is that they need to be installed on an indoor water meter. Most Arizona homes have water meters located outdoors, in a box in the ground. So, these products could not be used with those meters. Additionally, the FLUID [1] device has been halted due to

issues in manufacturing. Our team expects price to be the differentiating factor between current offerings and our new product.

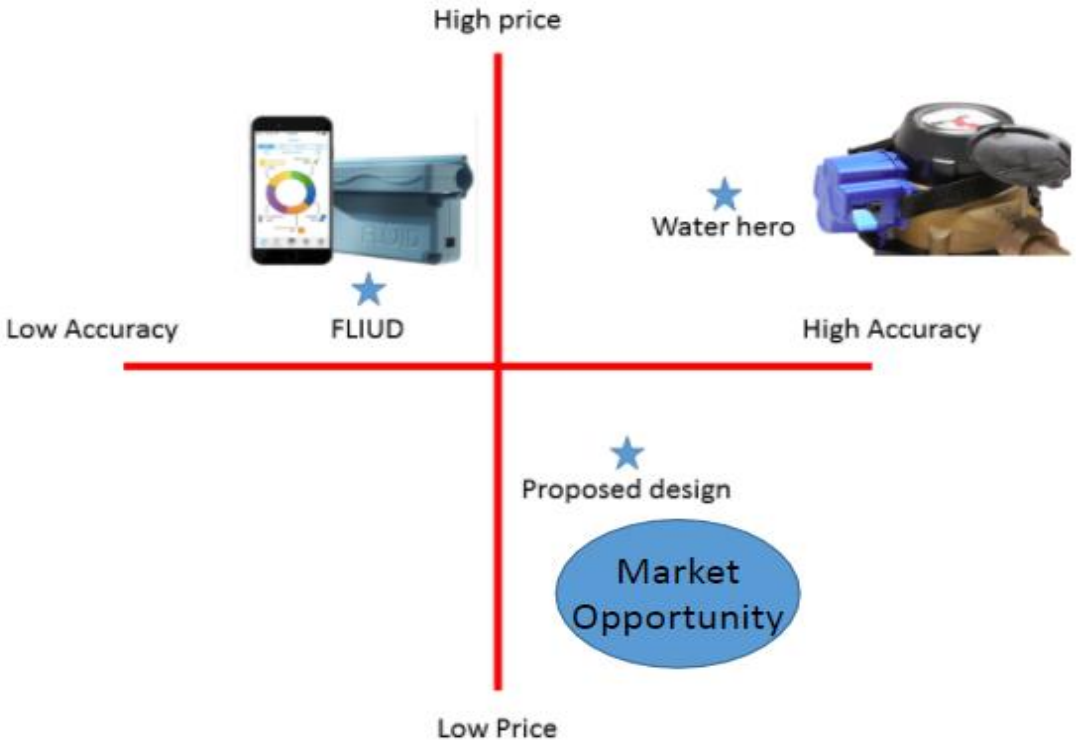

Figure 1: Market Opportunity

Our team conducted a survey to determine the preference of design attributes to the consumer of our water usage meter and to help us design according to those attributes. Another goal of the survey was to form a quantitative hypothesis that relates the design attribute to the probability of the population to purchase the unit with a given attribute. This data was obtained by using randomly generated choices, presented to the survey taker as a pair of choices (Discrete Choice Questions). By analyzing the collected data, the relationship between the levels of each attribute and the probability of selection are identified.

Survey data was collected from February 17th to February 20th, 2017, by distribution via social media, email and text messages. The data was collected from individuals that live in all types of housing and therefore the design attributes were chosen such that the outcome of the survey would not be influenced by the residence type of the poled individuals.

High accuracy is the most preferable attribute and not having available data via an application is second largest concern of the user. From the data we can see that people are very acceptable for the price target range we chose for our project. Within that price range, people are actually willing to pay more to acquire slightly better performance.

Our company is seeking an upfront investment of $50,000 to be repaid at fiscal year two. The money will be used to purchase equipment, software and office items to enable the employees and the company to be successful. Necessary facility and personnel items include office furnishings, mobile workstations, a laser printer, five MakerBot Replicator+ 3D printers and Inventor Pro CAD modeling software.

The office furnishings, mobile workstations and laser printer are necessary for company personnel to complete job functions including fielding phone calls and conducting meetings, answering emails from customers and printing or sending invoices. The engineering equipment is necessary for both designing and printing the meter reader equipment for the customers. Five 3D printers will be required to support the product volume we expect for fiscal year one. However, our projections suggest that only one software license for Inventor Pro is necessary to support our design needs on a part time basis.

Our company expects that only two full time, salaried computer programmers will be necessary, but will be paid out of revenue starting in fiscal year one. So, the upfront investment will not be used to pay the salaries of employees. A design engineer is necessary for mount prototyping and general CAD work. The company estimates 25 hours of work per week for the design. The company will source a part time design engineer until workload requires a full time employee.

Web application deployment will be handled by an outside company. Heroku offers Platform as a service (PaaS), with the added benefit of supporting multiple programming languages. By using this service, our company can avoid the startup and maintenance costs associated with operating a server.

Business will be conducted out of an industrial business park. Building requirements are a minimum of four offices for the employees, which we expect to require 1,000 square feet, as well as a small shop area of approximately 1,000 square feet to facilitate manufacturing, shipping, and product testing and development. Total office space will total 2,000 square feet. The office location must support convenience to shipping, supplies and commute. The average annual lease rate is approximately $12/sq ft/year.

Marketing will be used to improve overall awareness of the product and service. Advertising will be accomplished via industry journals, magazines, as well as web based ads. Another effective form of advertising is reaching new customers through “word of mouth” via referrals. To facilitate this, we plan to implement incentives for customer referrals. Incentives can include additional merchandise or extension of service, free of cost for qualifying customers. All products and services will be marketed and sold by our company as to reduce costs associated with retail markup.

Financial data

Table 1: Capital equipment and supply

ITEM	USE	INITIAL COST	ANNUAL COST	COST/PART*
Accounting services	company finances		$ 600.00	$ 0.20
Legal services	company finances	$ 12,500.00		
Furnishings	general office supply	$ 2,100.00		
Mobile Workstations	general office supply	$ 7,556.40		
Laser printer	general office supply	$ 540.00		
Internet connection	general office supply		$ 720.00	$ 0.24
Materials	general office supply		$ 400.00	$ 0.13
Boxes, scales, etc	general shipping			
5 MakerBot Replicator+	production	$ 12,495.00 **		
Property	production		$ 24,000.00	$ 8.00
2 Computer programmers	research and development		$ 100,000.00	$ 33.33
Design engineer (CAD models)	research and development		$ 2,800.00 ***	$ 0.93
Inventor Pro	software	$ 9,995.00		
Heroku	software		$ 500.00	$ 0.17
Total		**$ 45,186.40**	**$ 129,020.00**	**$ 43.01**

* 3000 in Year1

** $2499 per printer, 5 printers

*** Design engineer not necessary year around. Hourly payment of a CAD designer is $25. Estimated 112 hours of model design is needed in a year.

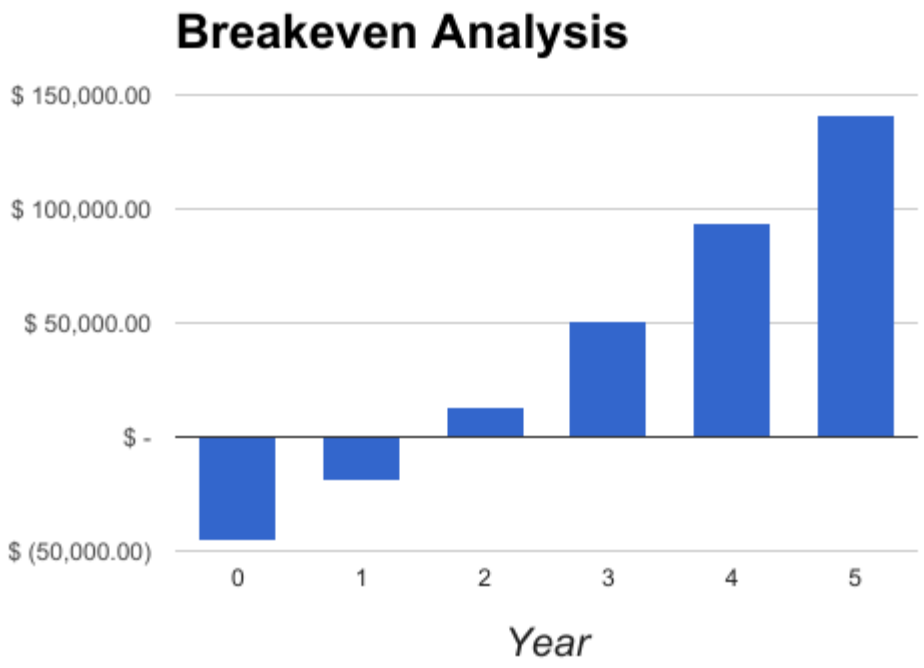

Figure 2: Breakeven Analysis

The breakeven analysis assumes an initial investment cost of $50,000. The annual operating cost is estimated at $129,020, which is then offset with a predicted annual income of $144,000 for year one. With this we break even during year 2.

The following analysis assumes several factors. First, a discount rate of 6% was used for financial calculation. Next, a volume growth rate of 10% per year was used to grow the sales of the company. Finally, we assumed starting sales and starting subscribers to total 3,000 during the first fiscal year.

Pro Forma

Table 2: Pro Forma

Price Per Unit	$50.00	
Cost Per Unit	$43.01	
Price Per Month (service)	$7.00	
Starting Sales	3,000	*
Starting Subscribers	3,000	*
Sales Growth Rate	10.00%	
Tax Rate	29.60%	
Discount Rate	6.00%	

Year	**0**	**1**	**2**	**3**	**4**	**5**
	2017	**2018**	**2019**	**2020**	**2021**	**2022**
Income						
Investment Amount	$ 50,000.00					
Total Sales (units)	0	3,000	3,300	3,630	3,993	4,392
Total Subscribers	0	3,000	3,300	3,630	3,993	4,392
Sales Revenue		$ 272,980.00	$ 300,278.00	$ 330,305.80	$ 363,336.38	$ 399,670.02
Expenses						
Initial Costs	$ 45,186.40					
Production Costs		$ 129,020.00	$ 141,922.00	$ 156,114.20	$ 171,725.62	$ 188,898.18
Other Costs		$ 104,300.00	$ 104,300.00	$ 104,300.00	$ 104,300.00	$ 104,300.00

Net Profit						
Gross Profit	$ 4,813.60	$ 143,960.00	$ 158,356.00	$ 174,191.60	$ 191,610.76	$ 210,771.84
Earnings *		$ 39,660.00	$ 54,056.00	$ 69,891.60	$ 87,310.76	$ 106,471.84
Taxes ***		$ 11,739.36	$ 16,000.58	$ 20,687.91	$ 25,843.98	$ 31,515.66
Total Profit		$ 27,920.64	$ 38,055.42	$ 49,203.69	$ 61,466.78	$ 74,956.17
Balance	$ 4,813.60	$ 32,734.24	$ 70,789.66	$ 119,993.35	$ 181,460.13	$ 256,416.30
Present Value	$ 4,813.60	$ 30,881.36	$ 63,002.55	$ 100,748.73	$ 143,733.42	$ 191,609.17
Breakeven	**$ (45,186.40)**	**$ (19,118.64)**	**$ 13,002.55**	**$ 50,748.73**	**$ 93,733.42**	**$ 141,609.17**

* Approximately 0.1 percent of the market share

** Earnings before interest and tax

*** Below standard deduction

Market size is constructed off the total number of U.S. single family residences. Based on the 2016 United States census, there is an estimated 98 million single family homes in the U.S. It is assumed that these single-family homes have individual water meters, and that 90% of the homes have not been updated to smart meters and still contain legacy water meters. This leaves a market size of 88 million households [2].

The market share is based off the survey results collected from 48 individuals. The survey showed that 31.43 of the individuals were interested in a water tracking solution with 7.14% of these individuals preferring a DIY solution to an off-the-shelf item. This left an estimated market share of approximately 2 million. First year subscribers and sales are approximated as 0.15 percent of the market share.

Supporting documents

Existing patents

Device for cell-phone shoot check meter fixed

CN 204576775 U

Patent Claims: 1. fixed phone camera meter reading device by mobile phone and fixed hood-shaped housing composition, both as one structure, characterized by: a circular through hole between the phone casing with the fixed cover; fixed cover conical may cover the mechanical meter head table; phone and fixed hood-shaped housing materials are transparent plastic.

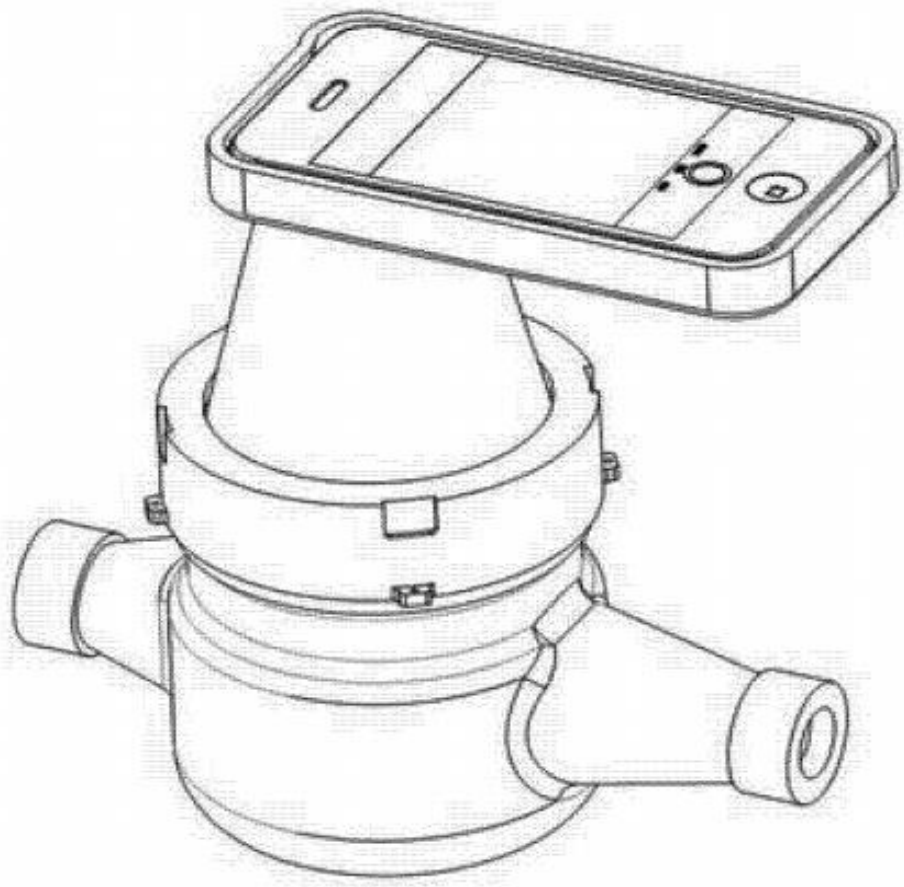

Figure 3: Device for cell phone shoot check meter fixed

This patent serves the same function as our product. While the mount is functionally the same as our design it does not share the same key features. The features are outlined in the patent claims, indicating that it is constructed out of transparent plastic with a cone shaped hood covering the face of the meter. The design offered by our company does not contain these key traits as ours is constructed of any color plastic and does not use the hood design indicated as a key feature in the patent.

Remote control water meter

US20100175766 A1

Abstract: The present invention an apparatus and system for remotely operating a combination water meter and shut off valve. The apparatus and system is operated by a computer at the utility sending a signal via phone line or radio modem to the meter. Once the meter receives the signal to close, a small solenoid will open. This will allow water to enter the fill chamber, causing the piston to rise. The top of the piston is connected to a gate valve. This valve may turn off the water supply to a customer's home. To turn the water back on, a signal can be sent again to the meter, opening the drain solenoid. This allows the water to leave the fill chamber. The piston is then lowered from the return spring, opening the gate valve, allowing water to flow.

Our current design does not conflict with this patent at this time since it does not contain a shutoff mechanism.

Web service application based optical character recognition system and method

US 7609889 B2

Abstract: The present invention disclosed a web based OCR system including an OCR service apparatus that communicates with a web browser of a client apparatus and an optical character recognition method for controlling the OCR service apparatus that communicates with the web browser of the client apparatus, the OCR service apparatus comprising: a storage unit for storing an image; a sending unit for sending the image to the web browser of said client apparatus; a receiving unit for receiving a control instruction of a character recognition process from the web browser of said client apparatus, wherein the received control instruction is generated in the web browser of said client apparatus; and a character recognition processing unit for executing the character recognition process for the image based on the control instruction. With such optical character recognition method and system based on web service application on a network, the user can get control of the recognition process flow and the efficiencies are improved.

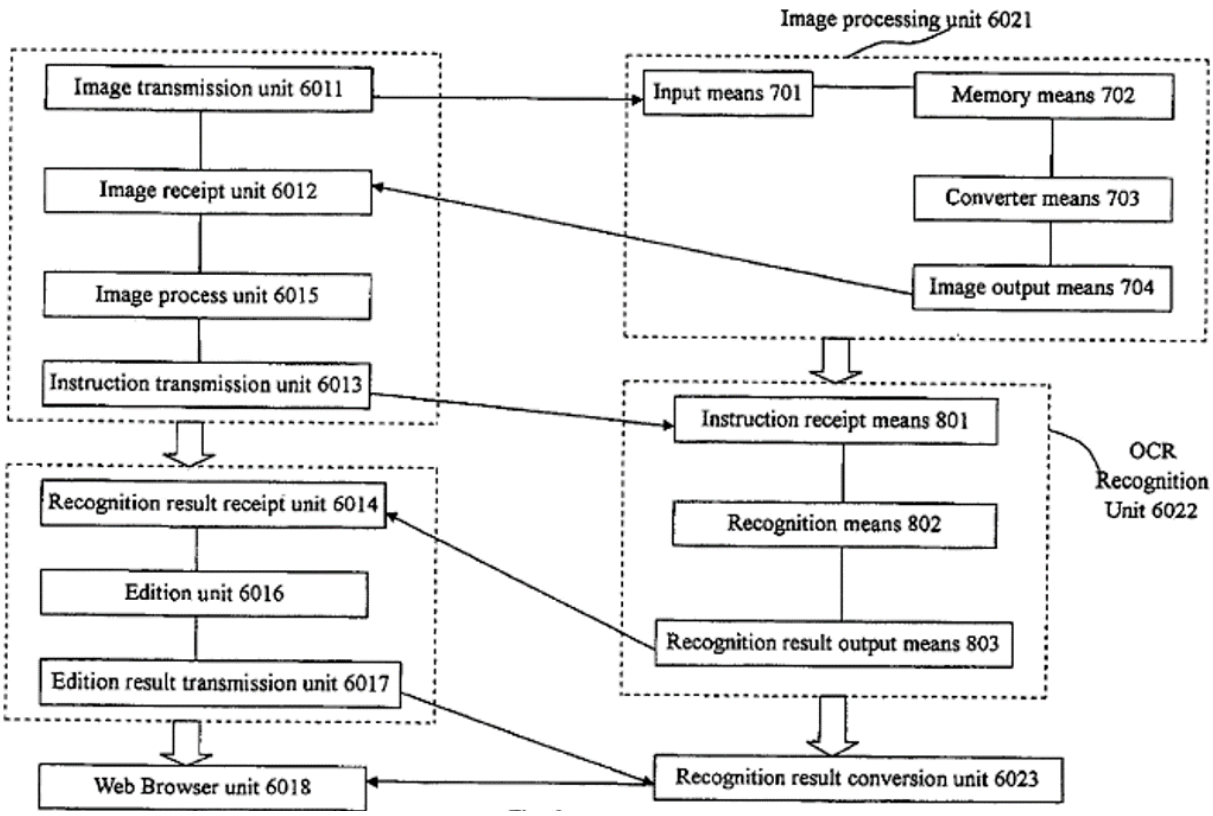

Figure 4: Web service application based optical character recognition system and method

This patent uses a different hardware and software architecture than our company's proposed design.

Optical character recognition by iterative re-segmentation of text images using high-level cues

US 20150055866 A1

Abstract: Disclosed techniques include receiving an electronic image containing depictions of characters, segmenting at least some of the depictions of characters using a first segmentation technique to produce a first segmented portion, and perform ing a first character recognition on the first segmented portion to determine a first sequence of characters. The techniques also include determining, based on the performing the first character recognition, that the first sequence of characters does not match the depictions of characters. The techniques further include segmenting at least some of the depictions of characters using a second segmentation technique, based on the determining, to produce a second segmented portion, and performing a second character recognition on at least a portion of the second segmented portion to produce a second sequence of characters. The techniques also include outputting a third sequence of characters based on at least part of the second sequence of characters.

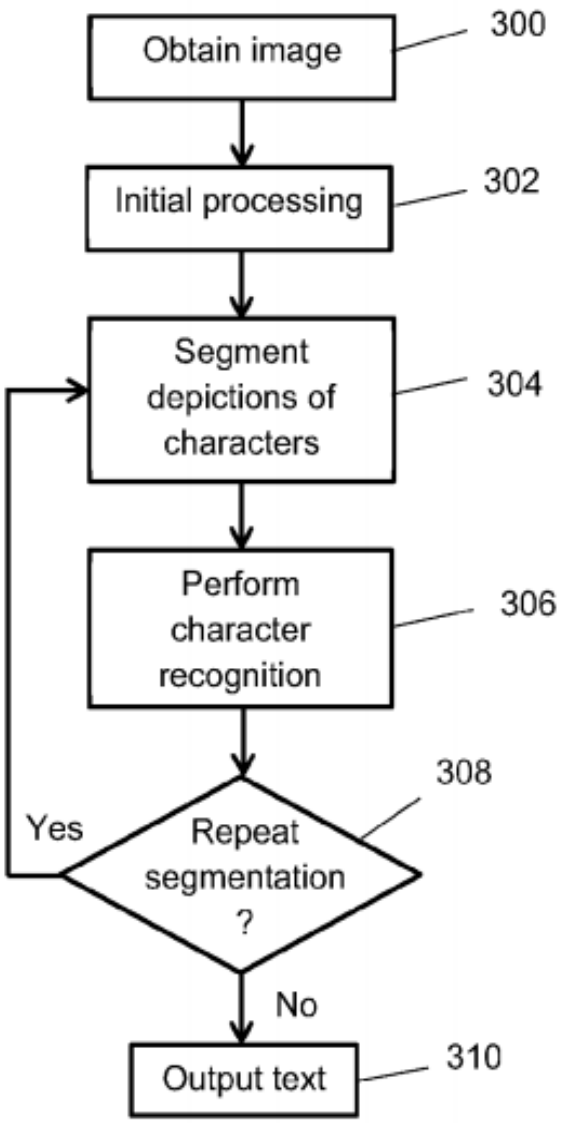

Figure 5: Optical character recognition by iterative re-segmentation of text images using high-level cues

This patent is focused on the segmentation of images for OCR using an iterative method. This is outlined above as taking place automatically. In our model all segmentation is performed manually. Keeping the segmentation fully manual prevents any patent infringement that could take place.

Technical analysis and benchmarking

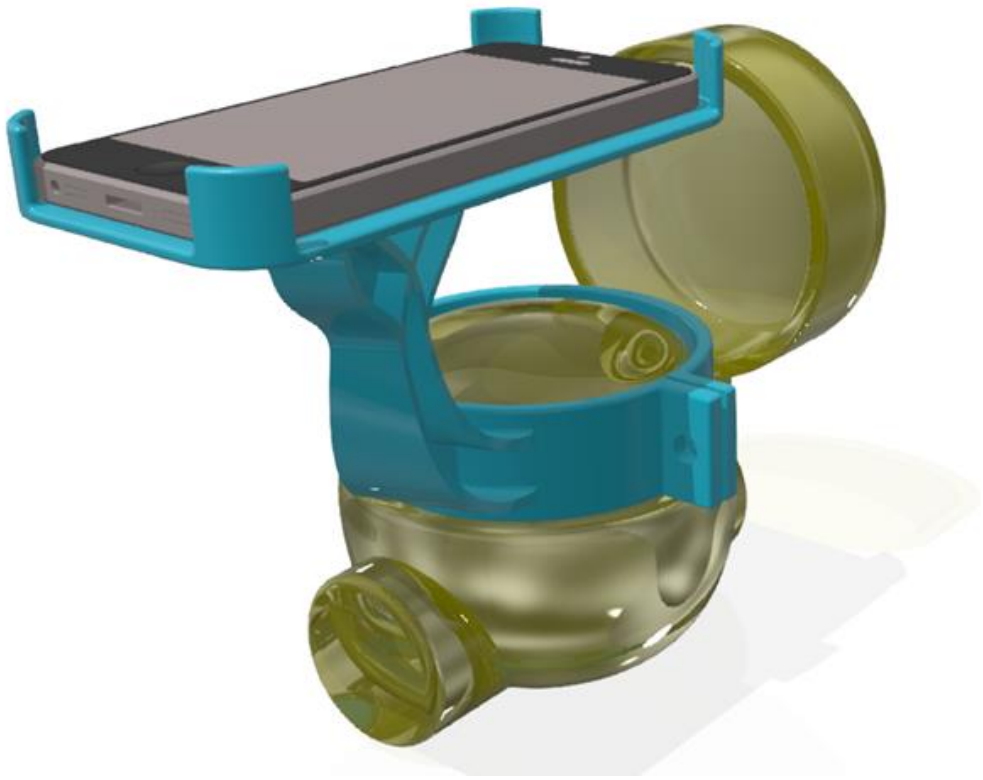

Figure 6: Water Eyes product rendered 3D model

Unlike many other products currently available in the market that use mechanical solutions, our product uses the power of software technology and machine learning. It is an add-on to the existing water meter and supplements it. The product can be broadly separated into hardware and software.

Software

The software technology behind our product is based on Optical Character Recognition (OCR) and Convolutional Neural Networks (CNN). A training model is built specifically for the digits of the water meter using a mix of MNIST dataset and digits obtained from the meter itself. This reduced the error due to false detection and incorporates the semi-visible rotary digit detection.

The software itself is split into two for optimal functionality. One part of it is on the client side to take the image of the meter, extract the digits, and convert and resize them. This can be easily loaded onto the mobile phone using a web browser. The other part is the server side, which houses the recognition software. It receives the images from the client, recognizes the digit from it, and sends it back to the client. It can also store the digits with a timestamp.

Sampling the data at a high rate provides a real time and in-depth analysis of the water consumption. It also can also detect spikes in the flow, in which a leak in the system is present. It can also detect slow consumption that may be associated with a low-level water leak. Therefore, targeting the major problem using an innovative solution.

Hardware

Hardware consists of a 3D printed mount and a retired smart phone. The retired smartphone is required to have a working camera and internet connectivity. The mount design consists of a base to hold the phone and has a hole for the camera view. Qualitative testing showed that the mount needs to resist torsional load as well as axial loads with minimal deflection.

The design of the mount must allow for it to secure to the legacy water meter by means of a clamping device. The mount must also resist movement as the camera must be precisely located. These requirements lead to a device that needs high flexibility at the clamp interface and low flexibility for the rest of the structure. Our company found that these traits could be achieved using ABS plastic.

Several design iterations and further optimization lead to a final prototype satisfying all constraints with a total volume of only $6.53*10^{-5}$ m^3. Reduction of volume was found to greatly reduce production material costs, as well as improve manufacturing times involved with 3D printing.

Figure 7: Clamp Design Requiring Ductile Material Properties

Figure 8: "I-beam" Design for Increased Rigidity

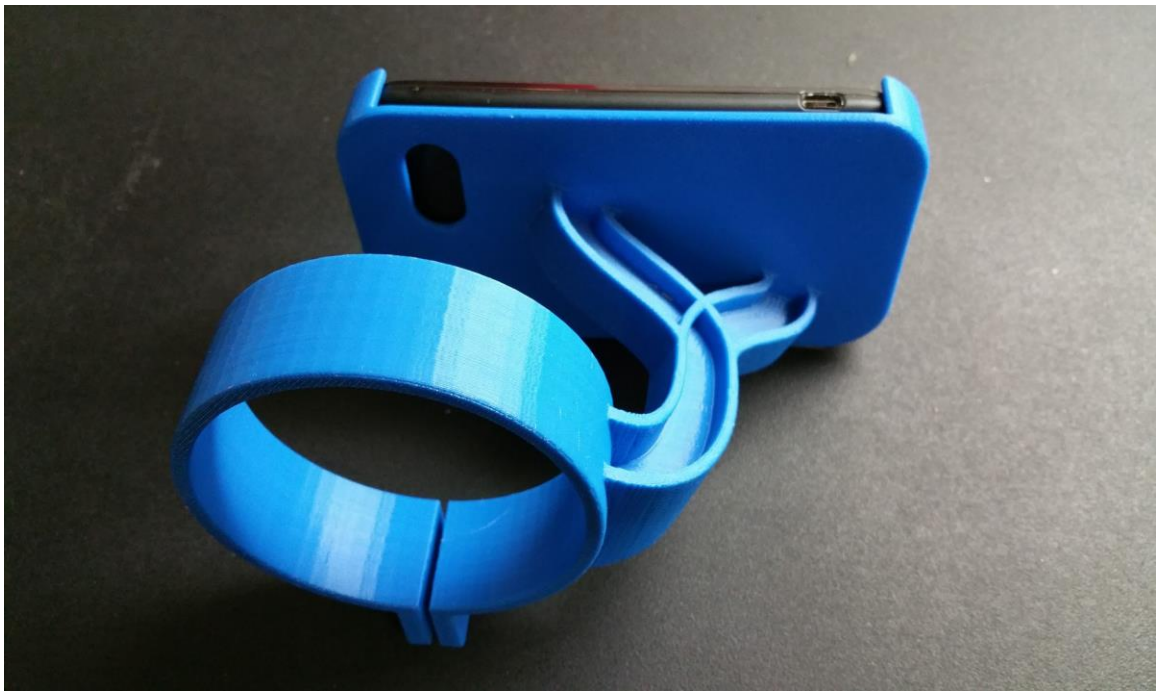

Figure 9: Prototyped 3D Printed Design

Current software limitations associated with the html embedded camera browser app currently only supports infinity focus. Our company does not know of any current software workarounds that will allow the camera to focus at the short distances required for character recognition. Because of the software limitations, a hardware work-around was necessary. Our company found a solution to this by using a pinhole filter on the camera of the smart phone.

Extended testing showed that a pinhole of approximately .010-0.015 inches allowed for a crisp image regardless of the camera's ability to focus. In testing it was found that foil tape worked the best due to its opaque properties. The final production product will likely contain the pinhole in the mount.

Benchmarking

Utility water meters must meet the ANSI/AWWA Standard C-700 for accuracy [3]. In order to meet this requirement, the meter shall register not less than 80 percent and not more than 101 percent of the water that actually passes through it. Meeting this standard will prove that our product is suitable enough for the field. Since the optical character recognition can achieve an accuracy of 99.9 %, we can say that our product has the same accuracy of the water meter.

A benchmarking comparison for accuracy could not be done, as both Water Hero and FLUID devices do not quote accuracy details. However, from a cost perspective, our product is by far the cheapest. FLUID costs around $259 and Water Hero was advertised at $159. Our product is 31% of the lower cost device, the Water Hero. As stated earlier, both of these competing devices require a power source, while our product can operate on the phone battery's power. (Charging the phone will still be up to the homeowner.)

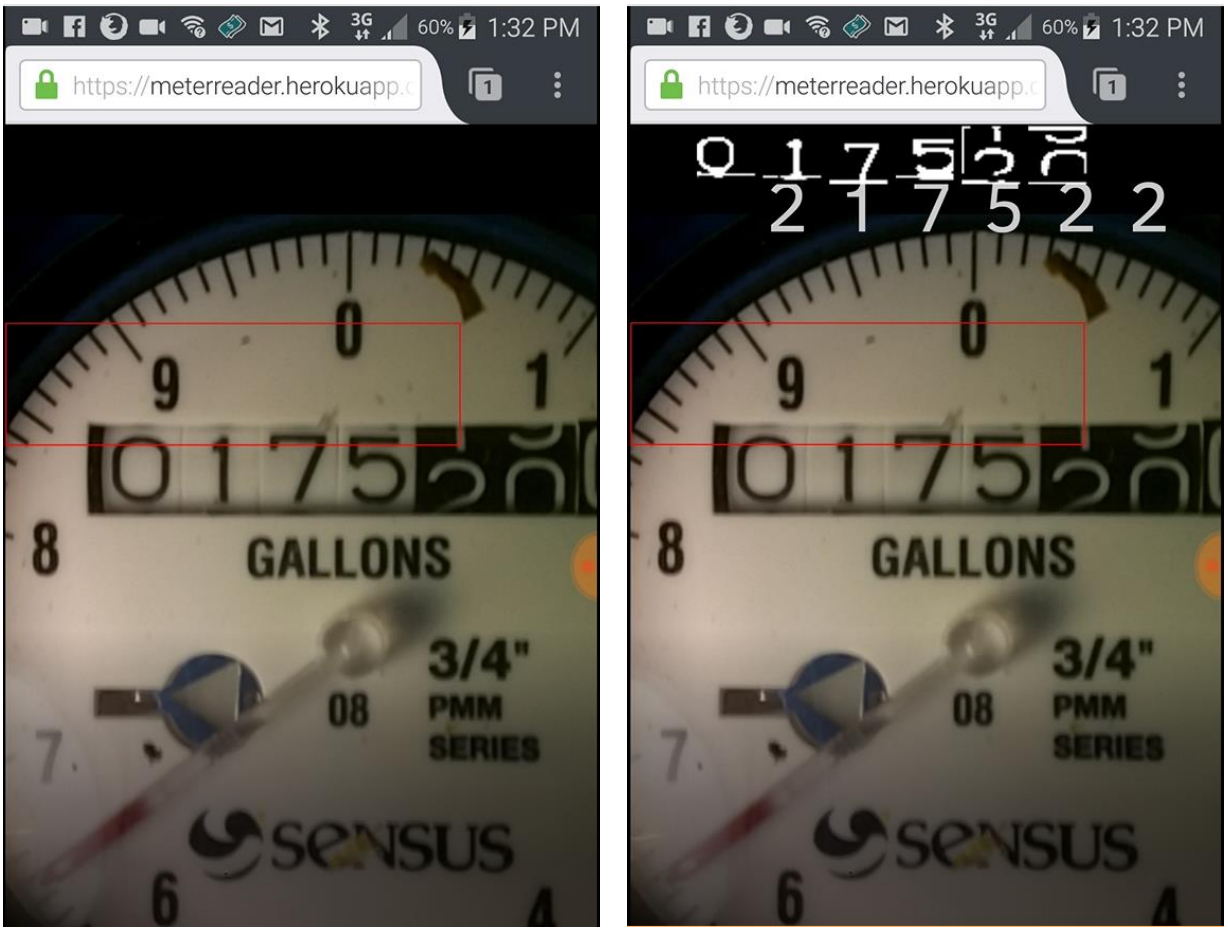

Figure 10: Screenshot from Field Testing

References

[1] FLUID, "Kickstarter," [Online]. Available: https://www.kickstarter.com/projects/825947844/fluid-the-learning-water-meter. [Accessed 28 January 2017].

[2] "Census.gov," [Online]. Available: https://www.census.gov/en.html. [Accessed 22 April 2017].

[3] NRDC, "Natural Resources Defense Council," 26 March 2013. [Online]. Available: https://www.nrdc.org/sites/default/files/wat_13032601a.pdf. [Accessed 15 Feburary 2017].

[4] U.S. Environmental Protection Agency, "Fix a Leak Week," 2 February 2017. [Online]. Available: https://www.epa.gov/watersense/fix-leak-week.

[5] "Water Leaks - Checks and Repairs | Home Water Works," [Online]. Available: http://www.home-water-works.org/indoor-use/leaks. [Accessed 1 February 2017].

[6] Research and Markets, "GlobeNewswire News Room," 27 May 2016. [Online]. Available: https://globenewswire.com/news-release/2016/05/27/843948/0/en/Smart-Water-Metering-Market-Worth-USD-5-51-Billion-by-2021-Focus-on-Water-Monitoring-in-North-America.html. [Accessed 1 February 2017].

[7] Water Hero, Inc, "Water Hero," [Online]. Available: http://www.waterheroinc.com/home/. [Accessed 28 January 2017].