Smart Bin - An Odor Oriented Approach to Waste Management

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ABSTRACT
Technology enhanced trash cans have already been subject to alot of research and have become available as market products. How the waste is handled has traditionally been a logistics issue, but it can also be approached differently.
The SmartBin perceives the trash as something more than a pile of waste - it is also something smelly!
The emphasis is on improving the indoor environment to ultimately improve the quality of life by detecting odors. The technology enhancing the bin uses sensors which detect gas emissions, mainly the ones occuring in decomposition of organic materials. If any of these values exceed a threshold the SmartBin will react accordingly.

ACM Classification Keywords
H.5.m. Pervasive computing, smart measuring: Miscellaneous

General Terms
Design; Measurement.

INTRODUCTION
Waste management is a constant issue, that is dealt with on the daily by different organisations. According to Eurostat, the countries in europe have had a rather stable production of waste the past decade, while some countries fluctuate towards higher productions of waste other countries produce less. citation needed The above supports the claim that waste management is highly relevant in a post modern society.

However waste management has traditionally been perceived from a logistical point of view. Imagine not the amounts nor the location of the bin being the driving force for interacting with it, but rather its smell.

This is the essential feature of our system - the additional parameter. This additonal information can be used in conjunction with existing systems or be used to produce an entirely new experience centered around the waste bin. Following this concept, a prototype of a simple system has been developed. The system produces information about smell and trash level for the bin entity it is installed on. This information is made readily available using a cloud-based system. We have one android application making use of the data. Its designed to be able to present in two different modes, namely as an ambient display or as an smartphone app. Figure 1 shows an overview of the system.

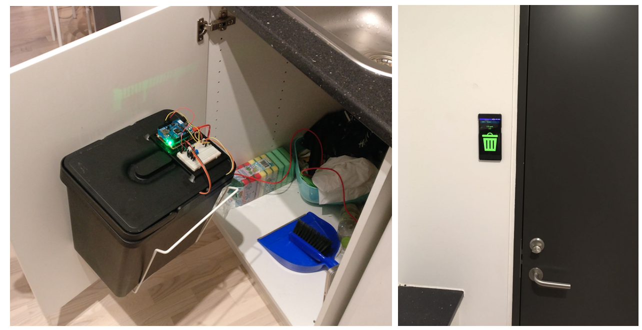

Figure 1. The SmartBin system overview, the bin with ambient display

The system is specifically designed for private use inside a household, but can be easily adjusted and extended for different usages.

In this paper we describe the system specifications and evaluation, and discuss its potential integration in other scenarios different from the one presented.

RELATED WORK
Smart Waste Management Systems (WMS) have been explored before. The usual approach is to explore the physical attributes of a bin, namely what is put in the bin. This information is usually used to perform advanced planning for collection of waste, or influencing people to adjust their behaviour in regards to what to throw out.

Some research groups implemented RFID and weight based systems for real time automated WMS, with the main focus on bringing down management costs and facilitate automating waste identification [6] [2].

In another study performed in South Korea, the main approach was to identify food waste in a selected area of Seoul and give citizens incentive to waste less food by fining them based on the amounts of waste they dispose [3].

In an italian study, performed by Vincenzo Catania and his colleagues in the city of Catania, a Smart-M3 Platform and sensor enhanced bins were used, this was done with the main focus on urban planning, smart collection and monitoring of urban solid waste [5].
In this case, the information that was collected was on the location of the trash can, level of fullness, and weight of the

Figure 2. The sensors.

waste.

The infrastructure used in the variety of systems tends to be similar. Usual approach is a centralized server and a host of devices providing data to the server.
The server is then used as a data provider for powering applications such as management utilities or phone apps.

SYSTEM DESIGN

Our approach includes the additional parameter of scent as a factor. Biology supports our claim due to the fact that some materials are decomposed over time. This decomposition has side effects, namely the production of certain gasses, which can be detected by a variety of sensors due to their multiple characteristics of density and conductivity. We are interested in the gasses easily detectable by humans - namely the ones with a characteristic smell.

Our system is composed of four main components, a *sensory layer*, a *communication module*, a *data layer*, and a *data consumer*.

Sensory layer and Communication module

The sensory layer has two sensors (figure 2) and one communication device. The sensors detect the state of the bin. Our approach relies on two kinds of information related to the state of the bin: smell and fill level. For this reason, the sensory part of the system is of key importance, since it enables the information to be perceived and registered by the system. An odor detection sensor is able to capture volatile organic compounds (VOCs) and other gases, typical by products of food decomposition, commonly associated with bad smell. Some examples are Hydrogen Sulphide (H_2S), Ammonia(NH_3), Toluene (CH_3) and others. The smartbin sends the raw values of VOC concentration to the data layer.

The other type of sensor is a ultrasonic distance measurement unit. This is used to get the distance to the bottom of the bin. This type of information is processed in the sensory layer to reflect the amount of thrash filled in the bin.

The raw values are then processed and formatted into something understandable for our data layer. The last step is to send the values using the communication module. In this study a WiFi adapter was used.

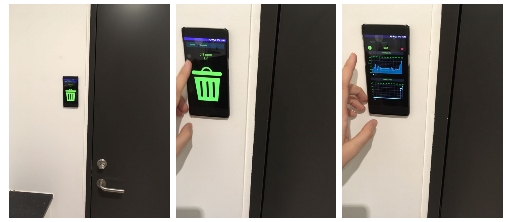

Figure 3. Interaction with ambient display

Data layer

The data layer is a simple restfull webservice for collecting the data and storing it in a database, making it accessible to potential consumers. The service supports two types of entities. The SmartBins and the contexts. In short a SmartBin represents the hardware instance of a smartbin, this includes information such as location expressed as coordinates, unique identifier, 'calibration' which is the intial air quality level (in "clean" air, a value to which compare later measurements) and meta information about the last associated context. This ensures that status of every bin is readily available without having to traverse the contexts. The contexts model a snapshot of a bins state at a given time.

Data Consumer

The consumer in our case is an android client, but could just as easily have been any other platform able to connect to the internet and present content.

Our client can work in two separate modes: either as an android application or simply as an ambient display(single bin mode).

On the android application it is possible to manage multiple bins and get an overview of the last values measured by the system.

The ambient display is much more simple, it just displays a color of a shade from blue to red depending on the scent level.

In our system we use an android phone to run in both modes, so pressing on the screen even in ambient display mode will give the user the extra functionality of knowing trash level and emission level.

Ideally the ambient display can be placed in a strategic location inside the house, for example by the door or on the fridge, where people can be reminded of the trash status and act accordingly.

Figure 3 shows an example of interaction with the ambient display.

HARDWARE

The Smartbin hardware platform is a simple construction consisting of two sensors, a microprocessor and a wifi communication module. It is embedded into a thrashbin with a lid which is used as a base for both the distance sensor and the gas sensor.

We built the prototype using an Arduino Uno board (figure 4). As for the sensors we used a Figaro TGS2602 as our gas

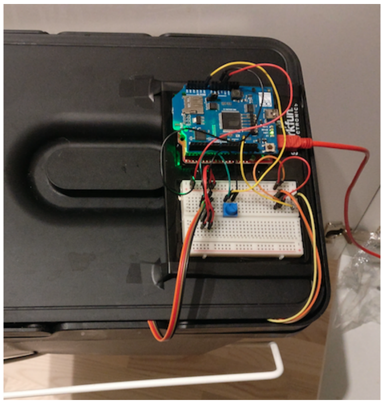

Figure 4. The controller board with communication shield

Figure 5. Cloud-based architecture

sensor and a MaxSonar MB1013 ultrasonic rangefinder as our distance sensor. We use a WiFi shield on the Arduino board for wireless communication.

The presentation layer works on Android 4.0 or later.

SOFTWARE

todo to mention: google app engine android stuff, api for graphs, others? arduino code detail?

The software consist of three components. The device on the bin, one cloudservice and one android client. The components interact using the client-server model over the web, in a cloud-based architecture (figure 5).

On the **bin**, the gas sensor first needs to go through a warm-up period of about 15-20 minutes, during which the sensor is energised. The resistance registered by the sensor drops sharply for the first minutes after energising, regardless of the presence of gases. This behaviour is commonly known as *Initial Action*, and could cause a system to mistakenly report presence of gases during the first minutes of activity [1].

After the warm-up period, the system will go through a period of *calibration* (5 minutes), during which the value Ro (resistance measured by the gas sensor in clean air) is computed as an average of 300 samples. During this period the sensor has to be kept in "clean air", or in an environment considered to be in a base condition, because later measurements will rely on this value.

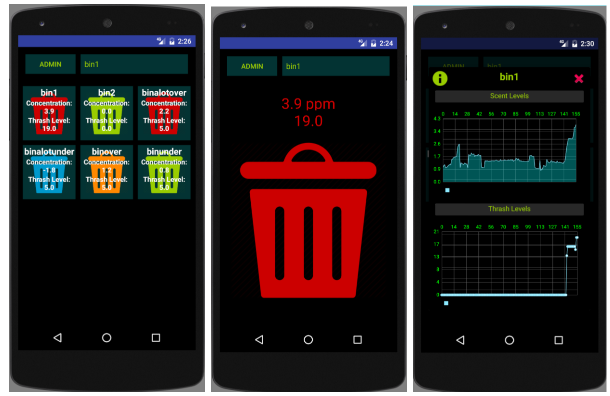

Figure 6. Image of the three main views in the android client

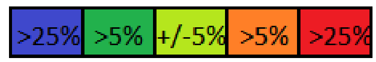

Figure 7. Image of the color codes ranging from deviation under the norm to deviation over the norm

After warm up and calibration, the gas concentration sensed by the sensor will be in the form of a ratio *Rs/Ro*, where Rs is the resistance measured by the sensor at a given time and Ro is the constant value detected in clean air. This means that if the gas concentrations perceived by the sensor are very similar as the ones in clean air, the ratio will be close to 1. The more the values Rs and Ro differ, the more far from 1 the ratio will be.

The cloud service is hosted using Google App Engine, it is a simple website that can present the state of SmartBins in the system. It also exposes a REST style API - which can provide SmartBins and Contexts. It uses technologies such as HTML, JavaScript, Java Servlets and schemaless persistant storage.

The android client can provide statistics about different smartbins - it only supports presentation of data in its current form. It supports two modes: **Admin mode** and **Single Bin mode**. Admin mode includes overview of every single bin and graphs for each bin. The graphs are only available as long as enough context information is present see figure 6.

Single bin mode provides a view of the current bin state.

The bin state is divided into five different categories, this is represented visually as colors. The order is, *blue*, *dark green*, *green*, *orange*, and *red*, as seen on figure 7. The middle one, *green*, is when the concentration is deviating with at most 5%, next tier *dark green* and *orange* is a deviation of at most 25%, and the last ones *blue* and *red* are deviations above 25%.

EVALUATION

The SmartBin system which has been constructed utilizes gas sensors to open up an additional dimension when measuring the state of the environment, in which it has been placed.

This extra dimension provides values of various gas concentrations in the current environment. In short these values will be used in an evaluation of how the current environment is doing in regards to air quality and potential safety hazards for individuals.

The expectation is that these results can be used to produce rather precise predictions about how smelly the air in the given environment is.

People have a notion about what smells, machines need to do these predictions based on values from sensors.

The assumption is that the gas emissions of some chemical reactions, namely the ones where decomposition of organic materials is happening, always produce some specific gasses as a product. It is based on our knowledge of these different gasses and how they smell - we assume that hightened concentrations of some of these gas types result in worse quality air.

System Evaluation

We interviewed a restricted poll of people in regards to usability of our system in a private scenario, and the results are the following: actual findings?

Multiple groups were used.

Group A where a homogenous group of people, all males and all ranging between the age of 20-30. They keep their thrash bin below their sinks in the kitchen, and some also have additional bins in the bathroom. The bathroom bins were not deemed that relevant due to the fact that most bathrooms are subject to having smelly environments post use.

Interviews collecting the opinion of the group were performed. The procedure was to present images of the bin and let the participants play around with the android application, followed by a non-chalant conversation of the system. All three people expressed that the system seemed like something obsolete. They were all really good at taking out the thrash. And the idea of having a situated display on either the wall or the outside of the thrash cabinet was stupid due to the fact that one could just open up and see.

all of the interviewed keep their private trash under the sink in a closed compartment

most of the interviewed consistently forget to take out the trash when they should

most of the interviewed think a reminder on the trash status placed on the door would be extremely useful to remember to take the trash out

evrybody think it's cool

stuff

CONCLUSION

The system described above is a simple implementation of what a private waste management system can look like. With the right IoT components, trash status can be easily monitored and transmitted. Modern sensors allow machines to perceive the same as what humans can, if not more at times, making it possible to even detect bad smell in our trash. Here is where our system separates itself from most of the other products in the same area. This extra parameter could be exploited to potentially be one of the leading information considered in waste management, together with the more canonical weight and amount.

While it remains true that trash handling is first and foremost a logistical issue, most waste management systems don't take bad smell into account. Our claim is that bad smell is actually a part of the problem when talking about trash management, both in the private as well as in the public.

While a private IoT "smart bin" that includes smell information would serve the ultimate goal of assisting in the process of garbage collection, it can be extended also for other purposes like data collection or as a perfume dispenser [4]. On the other hand, when approaching waste management from a urban point of view, the focus is often placed on the logistics: urban planning (where to place the bins, how many, ..) and on route planning for garbage collection. These systems usually rely on information on amounts of trash, being it height values or weight. Our claim not supported by proof is that smell information could also be relevant. rephrase or change, too tired right now

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