Microwave Oven with a Thermal Camera: Solving the Cold Spot Problem

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Abstract

We propose to alter a microwave so that it contains a thermal imaging camera and an android tablet. The microwave can then be controlled by heat maps and image recognition software. The tablet will be used for processing the input from the heat map, and for selecting the proper cooking parameters particular to the item to be cooked. The cooking parameters may be selected by UPC scanning or searched for by brand or description. The system will also allow remote viewing of the food being heated, an alarm for signaling the user that the food is done, and a few controls for extending or cutting the cooking time. Our end goal is to take the guess-work out of cooking food in a microwave.

I. Introduction

In the relatively few years since its invention, microwave oven technology has stagnated in its progress toward becoming a more efficient way of heating food and other items. Perhaps the greatest problem faced by modern microwave ovens are so called "cold spots". For example, when heating a frozen burrito (see Fig. 3), certain portions of the burrito will often heat to the right temperature, while other portions, such as the inside center, will still be cold. This is due to hot and cold spots in the microwave that coincide with the nodes (cold spots) and anti-nodes (hot spots) in the standing waves the microwaves create. Modern microwave ovens have used rotating turntables to try to combat the hot and cold spot problem, but this is only a partial solution [1].

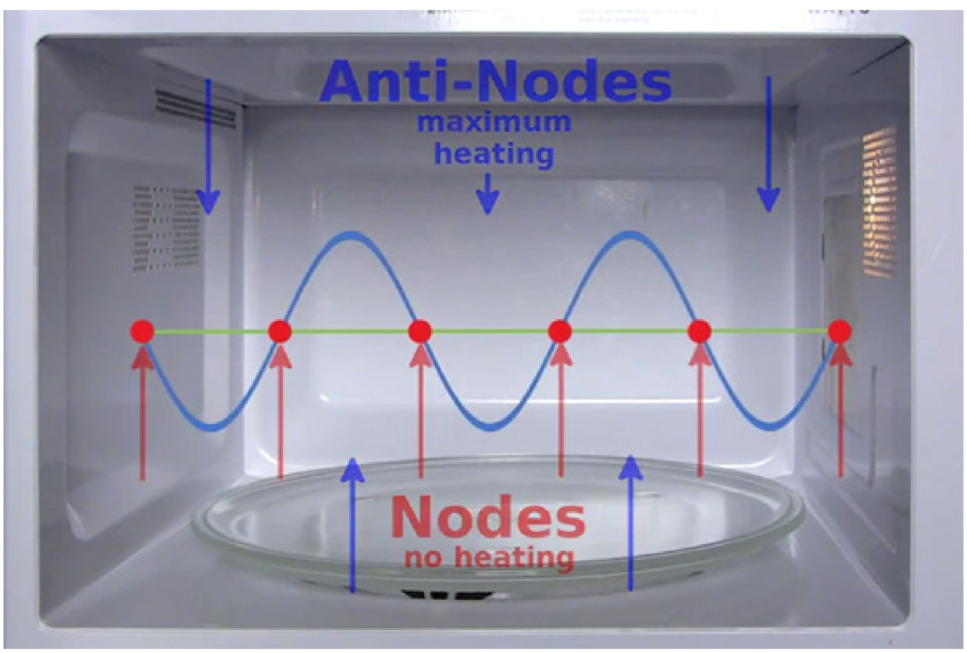

Figure 1. Microwave with simulated standing wave [2].

As can be seen in Fig. 2, the hot and cold spot problems are exacerbated by the thermal conductivity of water at different temperatures. Water actually conducts heat better when warm than when cold, so the parts of the food that are cold are even harder to warm up than the parts that are already warm. This is why "nuking" food by leaving it in the microwave for a long time will often fix the cold spots, but at the expense of overly-cooked sections. The solution to this problem is to turn off the microwave emitter at intervals during cooking and let the heat dissipate before continuing. This will increase cooking time, but will improve the quality of the food.

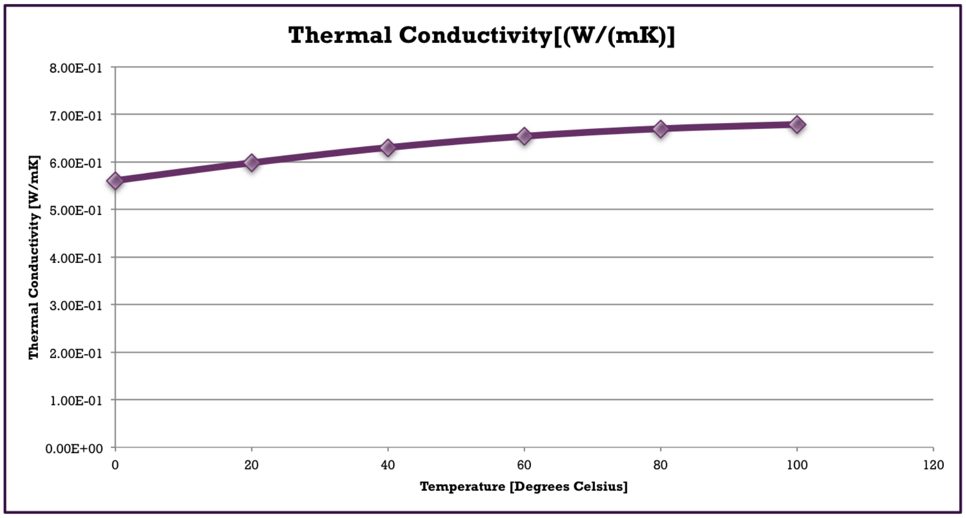

Figure 2. Graph showing thermal conductivity of water vs temperature [3].

Figure 3. Three examples of frozen burritos. This image shows the size and shape discrepancies between different frozen burritos [4].

What we propose is a more thorough, multifaceted solution to the cold spot problem. First, the microwave needs to know what food is being cooked! This will be accomplished in one of two ways: searchable data on Android tablet or by scanning the UPC code on the packaging. Searchable data will be used for cooking at the beginning and is the promised base-feature of the product. However, the UPC scanning is a stretch goal that would improve the user experience. Another aspect of this microwave knowledge is how the microwave "learns" new foods. Local storage is the simplest way, and is the promised base-feature of the product. Updates would be downloaded on a computer and then copied to the microwave via SD card or thumb drive. The stretch goal of the project would be to create an online, actively updated database that the microwave can query. The database would contain recommended cooking and resting times.

Second, placing a thermal imaging camera inside the microwave to obtain a heat map of the food being cooked is key to improving the quality of microwave cooking. Fig. 4 shows a thermal mapping of a frozen burrito as it is heated in a microwave oven. This heat map can be used in one of two ways. The first is simple and straight-forward: the image is displayed on an Android device, either the tablet on the microwave or over Bluetooth to a phone. This will allow the user to add more time to the cooking cycle (via controls on the app) without having to remove and test the food, which wastes heat and time. The second is a stretch-goal for the project: the images could be fed into image processing software that can be used by the microwave itself to judge the cooking level. Details as small as how long the food has been sitting on the counter before cooking can affect cooking time, and the image processing would allow the microwave to make minute adjustments on its own.

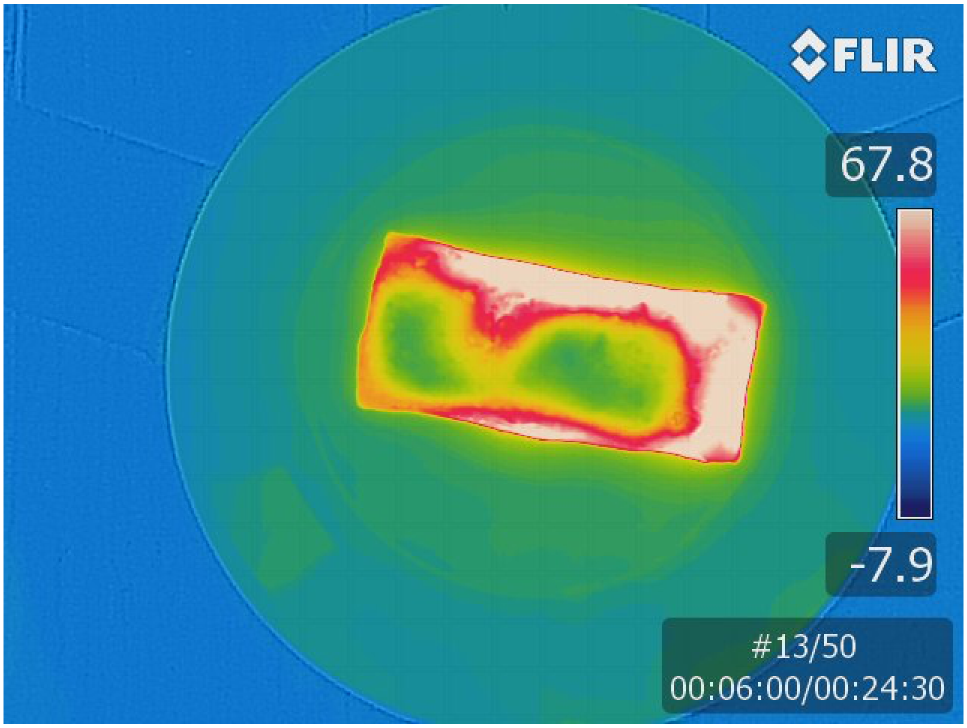

Figure 4. Heat map of a burrito in a microwave. The bar on the right shows the temperature gradient. Red, for example, is hotter than blue [5].

II. Background

The microwave oven was originally invented by accident in 1945 by Percy LeBaron Spencer [6]. Spencer was at the time employed by Raytheon and was working on a radar set. The high-power microwave beams emitted by the active radar set started to melt a candy bar he had in his pocket. Spencer decided to use this technology as a means to heat and cook food. To do this, he fed microwaves from a magnetron into a sealed metal box, so that the waves could not escape, creating a high density electromagnetic field within the box. The electromagnetic microwave radiation caused molecules in the food to build up thermal energy, thus cooking the food. Spencer's idea was patented in 1945 and a drawing of his design is included as Fig. 5.

In 1947, the world's first microwave oven, called the Radarange, was fabricated. The Radarange was about 6 feet tall and weighed 750 pounds. In 1955, Raytheon licensed its microwave technology to the Tappan Stove company who made and sold the first commercial home-use microwave ovens. But these were still very large and very expensive. Then in the 1960s, the microwave oven was finally miniaturized to a size and shape that could fit on a kitchen counter and in 1967, Raytheon introduced the first popular home model. Finally, in the 1980s electronic controls were added [7]. Since then, however, very little has been done in the progression of microwave oven technology... until now.

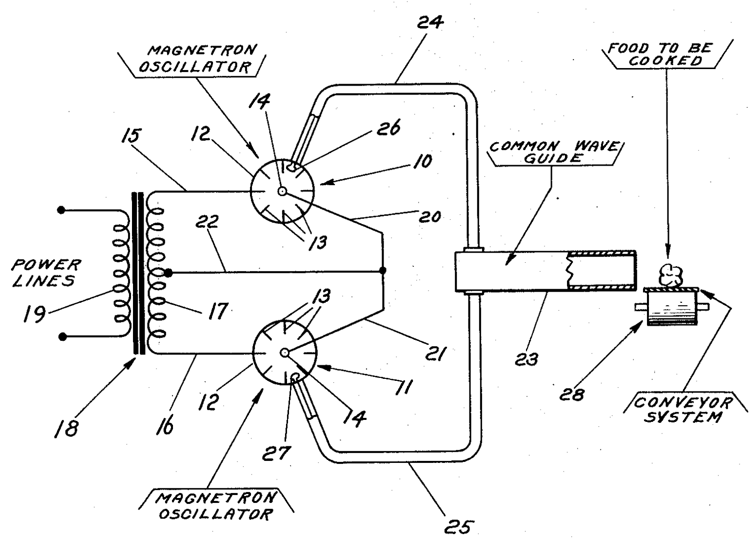

Figure 5. Microwave oven patent [6].

III. Appendix

A. Required Resources

Table I lists a tentative list of the resources required for this project.

B. Risk Assessment

Table II lists potential risks and solutions to be encountered in this project.

C. Schedule

Table reftab:schedule shows the proposed milestone schedule for this project.

References

[1] (2000) Why does a microwave oven have hot spots? [Online]. Available: http://www.colorado.edu/physics/2000/microwaves/hotspots.html/

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[4] Nick. (2012, Mar. 19) The homemade trials: Frozen burritos. [Online]. Available: http://www.macheesmo.com/the-homemade-trials-frozen-burritos/

[5] [Online]. Available: http://www.bettermicrowave.com

[6] S. Percy *et al.*, "Method of treating foodstuffs," Jan. 24 1950, uS Patent 2,495,429.

[7] P. Ganapati, "Oct 25, 1955: Time to nuke dinner," Oct. 25 2010. [Online]. Available: http://www.wired.com/2010/10/1025home-microwave-ovens/

Table I:

Required Materials			
Item	Price	Store	Information
Seek Thermal Imaging Camera	$249	Seek Website	The thermal camera that we will be mounting inside the microwave. The camera sensor is commercially available from the Seek website and interface-able with Android software via a USB go connection. We plan on asking Seek for an evaluation unit to cut down on costs.
Android Tablet	~$200	Google Store	We will check with Seek for tablet models that are compatible with their thermal cameras. Ideally we want a fairly large tablet, and it must be USB Go compatible. Possibilities may include the Asus MeMO Pad 10 and similar tablets.
Microwave	~$40	Walmart or other retailer	We will purchase a no-frills microwave that will be simple to retrofit with a thermal camera. If our prototype functions well and we feel that we have the time / resources, we may consider working with a larger microwave that includes a turntable.
Micro-USB extension cord	Already Own	N/A	Will be used to extend the camera connection camera to the tablet.
Android Studio	Free	Android Studio Website	We will use this IDE to program the tablet for use in our application
Arduino (or similar)	~$30	Arduino website or similar	For prototyping, we will use a pre-constructed embedded system for controlling microwave from the tablet. The Arduino will interpret the information sent from the tablet and will control the heating cycles in the microwave accordingly. If we have time after initial prototyping is complete, we may consider creating our own application specific embedded system to control the microwave.
Possible Android to Arduino bridge (shield or the like)	~$30	Arduino website or similar	We may need to have some sort of interfacing bridge linking the microwave and the Arduino to control relay switching, motor control, etc. We plan to achieve this at first in our prototyping by using a commercially available Arduino shield or shields to make our work simpler. If we have the time / resources, we may implement our own chip setup that includes all the necessary components to omit a shield.

Table II:

Potential Risks and Solutions	
Potential Risk	**Potential Solution**
Interfacing microwave with heat sensor with Android not as simple as planned.	Create our own simpler interface, potentially not using Android (Arduino instead).
Barcode scanning doesn't work.	Cooking instructions will have to be entered by hand or the generic settings will have to be used for that food.
'Cold Spot' problem cannot be solved satisfactorily.	We can still offer a thermal imaging solution that can be viewed on the tablet or on a phone so that the user can decide on doneness on their own.
Broken parts (inexpensive)	Replace parts as quickly as possible.
Broken parts (expensive)	Cry... and try to replace parts as quickly as possible.
Parts too expensive	Search for less expensive parts or find a sponsor. We are going to try to get cameras from Seek for free. We have price-checked most of the items and they are within budget.

Table III:

Proposed Schedule	
Date	Milestone
By March 31st	Find all the sources for our proposed parts - Stuart
By April 30th	Order all the needed parts for prototyping - Darin
By May 31st	Explore the needed support hardware for having a thermal camera inside of a microwave. Start designing the software to interface with the thermal camera and the Android tablet. - James
By June 30th	Have the software for communication between the camera and the Android device finalized and working. - Stuart
By July 31st	Continue working on software integration. Start the hardware construction and the re-purposing of a microwave. - Darin
By August 31st	Work on putting the pieces together and work towards a functioning prototype, including hardware and software interfacing. - James
By September 30th	Begin testing out our implementation and test with an actual microwave. Continue debugging. - Stuart
By October 31st	Have a functioning prototype. This prototype would fulfill our senior project, but if we are able to get this done early, we have the options of expanding our project to be more our own, including our own embedded system implementations. - Darin
By November 30th	Continue to debug and solidify our hardware in preparation for demoing our project. Make sure all of our documentation is up to date. - James
By December 15th	Have a demo-able finished project. - Stuart