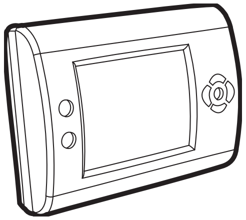
Product Overview

thermoSmart is an after-market home heating system that creates temperature zones in single zone homes.

Our main goal is to increase the efficiency of forced hot-air home heating systems while simultaneously improving the comfort of the users.

The Parts

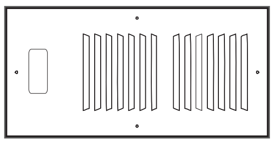


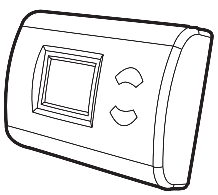
Coordinator

The Coordinator syncs all smartGrates and smartTemps in the user's home in a central location.

smartGrate

The louvers of the smartGrate automatically adjust to increase or decrease airflow into a room.



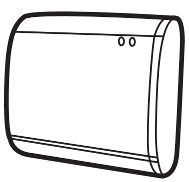


smartTemp

The smartTemp allows a user to adjust their desired temperature within a room.

HVAC Controller

The HVAC Controller interfaces with the furnace and signals the furnace to turn on or off.



Optimization Purpose

The optimization algorithm is used to define the louver positions in each room depending on the room's desired temperature and current temperature.

It will be used by the Coordinator when communicating with the grates.

Orange Team

Team Members:

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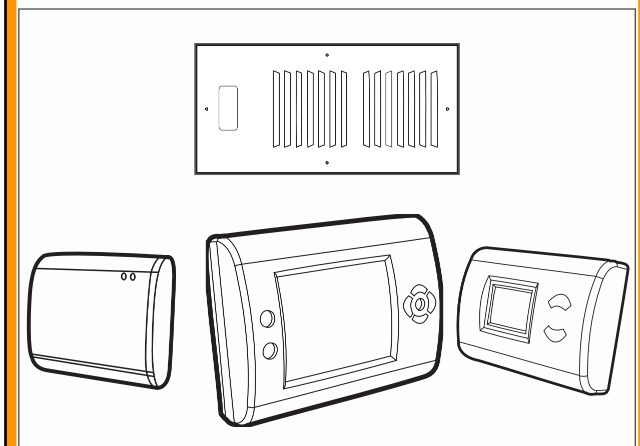
thermoSmart

Saving energy does not require sacrifices in comfort!

thermoSmart

2.009 Orange Team Final Presentation 12/8/2008



Optimization Overview Technical Brochure

Optimization Overview

Outline of Optimization Methods Tested

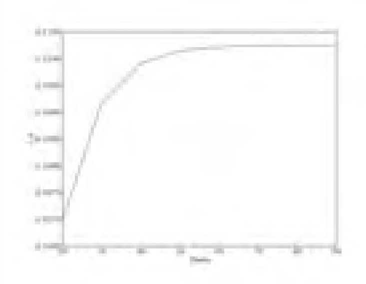
We tested several algorithms and found that allow the grate louvres to have three positions was the best for minimizing heat up time of rooms.

The algorithms tested were:

1. Idealized optimization
2. Isolation of Variables
3. P-Score method
4. Linear Regression
5. Three Position Control

1. Idealized Optimization

- Determines position of the louvers with 1-degree precision by optimizing flow rates into each room
- Our system doesn't measure flow rates, but this algorithm was used as a comparison for further algorithms to match.

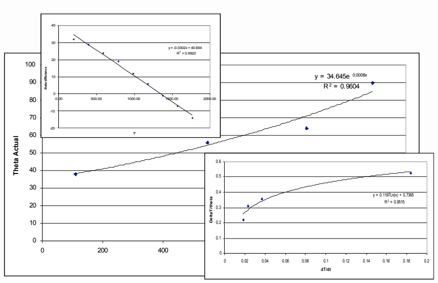


$$\frac{\left(\frac{T_{desired}-T_{room-current}}{\frac{dT}{dt}}\right)_{room}}{\left(\frac{T_{desired}-T_{room-current}}{\frac{dT}{dt}}\right)_{\max}} = X$$

$$v_{room} = X v_{\max}$$

2. Isolation of Variables

- Intelligent guess and check
- Determine relative effect of independent variables, e.g. number of rooms, different room sizes, different desired temperatures
- Relationships between grate position and each variable was not consistent--impossible to account for all possible scenarios



3. P-Score Method

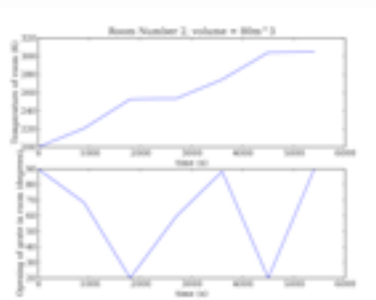
- Incorporate past room temperatures as well as past grate temperature values in determining the new grate position
- Led to unreasonable values for grate openings

$$\sum_{i}^{rooms} \frac{T_{room,current}-T_{room,past}}{\theta_{previous}\cdot t_{check}(T_{desired}-T_{room,current})} = P_{room}$$

$$\theta_{room} = \frac{P_{room,\min}}{P_{room}}\cdot 90^{o}$$

4. Linear Regression

- Change in temperature of the room (dT/dt) is a property of the room
- Use this measured value to determine theta with respect to the desired temperature increase
- Theta and temperature changes are not linearly related and thus results are unreliable
- Oscillating theta values result in inefficient use of battery power



$$\frac{\left(\frac{T_{desired}-T_{room-current}}{\frac{dT}{dt}}\right)_{room}}{\left(\frac{T_{desired}-T_{room-current}}{\frac{dT}{dt}}\right)_{\max}} = \frac{\theta}{90}$$

5. Three Position Control

Our Algorithm

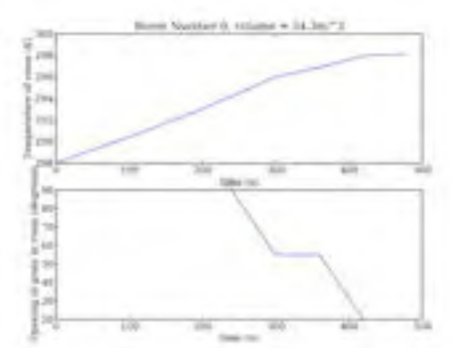
- 3 positions (90, 55, and 20 degrees)
- Time step of five minutes (time to check if grate should move)
- Servo is not actuated every time step if the algorithm finds it should stay in its current position --leads to longer battery life
- Time to reach desired temperatures is in between the idealized optimization and our simulation for normal systems (all grates full open)

For Each Room:

- if $T_{desired} - T_{room,current} \geq T_{current} - T_{room,past,time,step}$

  then $\theta_{room} = 90^{o}$
- if $T_{desired} - T_{room,current} < 0$

  then $\theta_{room} = 20^{o}$
- in all other cases, $\theta_{room} = 55^{o}$



Time to temperature:

- Our system is capable of reducing heat up time of rooms by up to 15%!
- Over one heating season, this is equivalent to taking 2 cars off the road!