HEAT - HOME ENERGY ASSESSMENT TECHNOLOGIES: A WEB BASED SYSTEM FOR RESIDENTIAL WASTE HEAT ANALYSIS USING AIRBORNE THERMAL IMAGERY

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Convergence in Geomatics: Challenges and Opportunities The Role of Geomatics in Decision-Making: Providing Real Value to Canada’s Economy and Society

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ABSTRACT:
We report on the HEAT (Home Energy Assessment Technologies) pilot project conducted over the city of Calgary, Alberta, Canada and discuss plans for the 2010 full city implementation. The objective of HEAT is to provide free web tools to (i) evaluate and monitor residential thermal envelopes (i.e., waste heat) using a Thermal Airborne Broadband Imager (TABI), (ii) provide assessment information to individuals regarding their home’s energy usage and savings, along with potential CO$_2$e (Carbon dioxide equivalent) footprint reductions, (iii) support Canadian urban energy efficiency programs. A demo version of this service can be accessed at http://www.wasteheat.ca (login: beta, pwd: beta). We welcome your constructive feedback.

1. INTRODUCTION
Since 1990, Canada has encouraged energy efficiency by implementing numerous incentive programs. For example, in Calgary Alberta, $50 million was spent between 2003-2008 on energy performance programs to assess and upgrade city owned facilities, with an estimated $7 million saved in energy costs per year and a reduction of $80 KT of CO$_2$ emissions (DEEAEP, 2010). The key for these savings was that appropriate information provided action to enhance energy efficiency and reduce environmental impact (Darby, 2006). But how do local home owners concerned with reducing their environmental footprint (in terms of both energy usage and emissions) know that their home – not the energy saving devices used inside it – is energy efficient?

Here we report on the goals, methods and results of the HEAT project (Kyle, 2009): namely to develop a Geomatics turn-key solution (software, hardware, data provision and web-portal/service) that will freely provide residents a way to automatically assess their home’s thermal waste energy footprint (i.e., a detailed heat map of their home showing hot and cold areas), to identify where potential energy saving renovations could be made (i.e., windows, roofs, etc...) without the need for costly and potentially unnecessary in-situ thermal surveying taking place; and all as easily as clicking on Google maps. With this knowledge, home owners can participate in government grant/tax incentive programs to carry out energy saving renovations on identified areas, from certified service providers (Hay and Kyle, 2009).

2. STUDY AREA AND DATA COLLECTION
2.1 Study Area
The pilot project study area is located in the community of Brentwood, situated in the northwest of Calgary, Alberta, Canada. This site encompasses 360 residential buildings, the majority of which were built between 1961 and 1965 – suggesting that they are good candidates for potential energy saving renovations.

2.2 Data Collection
A 600 x 2000 pixel TABI-320 geometrically corrected mosaic of the study area was provided by ITRES Research Limited, Calgary. The TABI-320 is a push broom thermal infrared sensor that produces an image 320 pixels wide. The sensor is sensitive to the 8μm - 12μm range of the electromagnetic spectrum and captures flight information that is later used to geo- and ortho-correct the imagery. The image was delivered in ENVI format with a spatial resolution of 1.0 m and a radiometric resolution of 0.1°C. A new larger area dataset will be acquired by the TABI-1800 during the spring of 2010. This new sensor is capable of collecting 1800 pixels per swath, effectively 5+ times the current capabilities of the TABI-320, in one fifth the time and cost (TABI, 2010).

3. METHODS AND RESULTS
3.1 System Architecture
HEAT is a Web 2.0 project developed primarily using Free and Open Source Software (FOSS). It uses OGC (Open Geospatial Consortium) compliant standards for geospatial and location based services. Python (a dynamic object-oriented programming language) is used for rapid development. PostgreSQL enabled with PostGIS is used along with Python to handle the geodatabase. IDL (Interactive Data Language) is used for image processing. Figure 1, shows the system components of HEAT.
3.2 User Experience:

When first logged into the HEAT website, a smooth interpolated layer becomes visible. This layer provides an overall map of the area’s waste heat distribution. As a user moves (i.e., mouse’s) over the interpolated layer, different (pseudo) community boundaries appear. Once a community is clicked its corresponding waste information is displayed in the Community Waste Heat Information & Distribution section (Figure 2).

This popup window contains the following information (i) a pseudo-coloured thermal image of the home, (ii) Minimum and Average roof top temperature, (iii) 3 Hot Spots - showing the 3 hottest points on the roof, (iv) a Fuel Table - showing the cost of heating the home per day and their corresponding CO₂ (Carbon dioxide equivalent) in kg/day for various fuel types, and (v) a Savings Tab, that can be access in two ways: (a) by clicking on it or (b) by clicking on a fuel type in the fuel table. A click links to the Savings Graph (Figure 4) which displays the modeled cost ($) and generated CO₂ for heating the house for a year. It also models the amount of savings ($) and CO₂ reduced when the roof top temperature is reduced to the minimum temperature observed. These reductions may be achieved by increasing insulation, or improving roofing, windows, doors, other vents or the heating system. The Fuel Table and Savings Graph are based on models from The Urban Archetypes Project, a community case study for the City of Calgary (The Urban Archetypes Project, 2007).

A number of specific results and innovations unique to this project include the following: (1) The development of a new commercial waste-heat monitoring market for TABI sensors, (2) The development of automated/semi-automated Geographic Object Based Image Analysis solutions (i.e., GEOBIA tools/software) (Hay and Castilla, 2008) to generate GIS ready house polygons directly from airborne thermal imagery, rather than from pre-existing city cadastral datasets. This is critical when cadastral data are unavailable, thus allowing web accessible results within a week of data acquisition. (3) Monitoring may be applied yearly to provide evidence of successful Government EcoEnergy retrofit programs. (4) Multiscale analysis can also be conducted ranging from individual homes to neighbourhoods, communities and cities, with opportunities to promote national and international intra- and inter-city heat waste competitions. (5) There is also potential to influence Calgary public energy-use by developing a web-enabled Thermal Energy Index as part of Calgary’s public cadastral information. This will be similar to the walkability
4. DISCUSSION AND CONCLUSION

Based on location-aware web services and high resolution airborne thermal imagery, the HEAT pilot project presents a Geomatics solution with a high potential for commercialization and advanced spatial decision making, that are applicable through a range of scales from the individual home owner, the neighbourhood, the community, to an entire city (Hay et al, 2010). Based on the ease and ubiquity of internet access, we forecast this project to provide community, commercial, and environmental utility on a global basis while promoting Canadian excellence in Thermal Imagery and location-aware web services. To evaluate the current version of HEAT, please login as (beta) to (http://www.wasteheat.ca) with the password beta (no italics). Please note that this system is in continual development, so we invite you to provide us with your constructive comments and feedback and welcome collaborative opportunities and partnerships.

5. FUTURE WORK

The development of the new TABI 1800 sensor represents an opportunity to acquire thermal data over large city areas in less time, and at a lower cost than previous TABI sensors. This opens up possibilities to develop waste heat monitoring for the entire city of Calgary (25 x 35km), which can be used as a test bed for other cities world-wide. More accurate house energy models are being developed by exploring the relationship between roof top temperature and building construction.

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