Open Carbon Footprint Calculation Platform for Personal Users

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1. Introduction

As climate change becoming an important global issue, more and more people begin to pay attention to reduce greenhouse gas emissions. Reducing GHG emissions needs to measure the emissions in specific areas, and to identify the major GHG emitting activities. Based on the knowledge of the major emitting activities and their impact on the environment, domain experts could build quantitative models and propose solid mitigation strategies and plans.

To measure personal or household carbon dioxide emission, there are already plenty of carbon footprint calculators available on-line. Most of these calculators use quantitative models to estimate carbon emission caused by the user's activities. Although the calculators can promote public awareness of the carbon emission from individual behavior, there are also concerns about the consistency and transparency of the existing carbon calculators [Padgett,1997]. Apart from a small group of smart phone carbon footprint calculation applications, most of the existing carbon calculators require users to input the data manually. This not only provides poor user experience, but also makes the calculation less accurate.

In this paper we are going to propose our approach to design of an open calculation platform for individual users. The platform maintains a model registry for quantitative human activity-carbon emission models used for calculation, and it uses on-line data services and sensor data as major source of input. In the following section, we'll introduce the data structure of the model repository and the carbon footprint calculation mechanism.

2. Carbon Footprint Calculation Platform

2.1 Model Representation & Quantitative Model Registry

In our practice, the quantitative models used for calculation carbon footprint could be local computation functions or web services provided by a third-party. As depicted in Figure 1, the system uses a three-attribute structure to describe a quantitative model. The three attributes represents the requested inputs for calculation, model restraints and the model's calculation error. The restraints attribute of a model can also be divided into general restraints and trigger restraints: the general restraints shows under what circumstances the model is capable of doing the calculation within the model error; while the trigger restraints represents when the model should be activated for calculation.

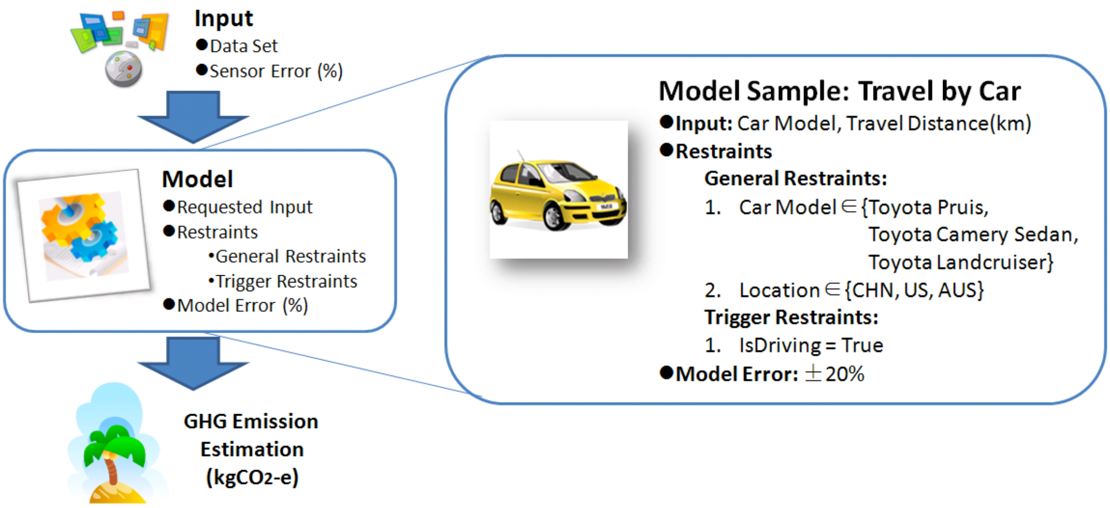

Figure 1 Basic Idea for Calculation of the Carbon Calculation Platform

To build the model registry, we use a decomposition tree structure to store the models' information. The root node of the tree structure represents the goal of calculating Personal Carbon Footprint, while its descendant tree nodes represent the specific calculation goals in specific areas decomposed hierarchal from the top goal. Each tree node in the model registry tree structure has two attributes: one is the average personal carbon emission amount of the area that the node represents; and in the other attribute is a model set of all the models which could calculate the personal carbon footprint in that specific area. For a specific user, a set of models could be selected by comparing time, location, and data availability against the models' restraints.

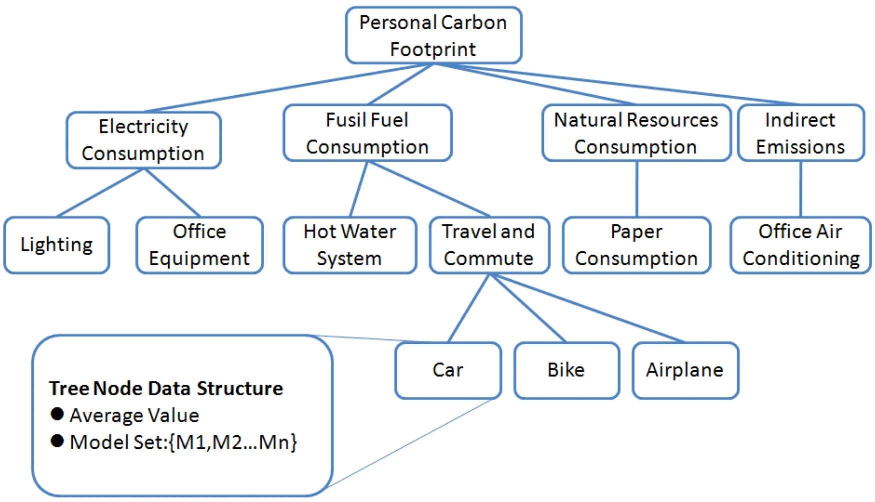

Figure 2 Sample Hierarchal Human Activity-Carbon Emission Model Registry
(Adapted from Reference [4] Measuring and Reducing the GHG Footprint of a Small Office)

2.2 Model Selection, Integration and Carbon Footprint Calculation

As the quantitative models and their registry being defined, we need a systematic method to select applicable models for particular users, and integrate the models to calculate the users' personal carbon footprint.

We could treat the tree nodes in Figure 2 tree structure as high level calculation goals, and quantitative models as operational tasks that support the upper goals. To prevent overlaps in calculation, the system adds conflict relations between operational tasks supporting the same or overlapping upper goals.

In this way, the job of selecting a set of non-overlapping quantitative models could turn into the opeationalizing the top goal. Based on the settings for specific users (shown in Figure 3), the system can select a set of applicable quantitative models from the model registry. Because all the quantitative models result is in kilograms of carbon dioxide equivalent GHG emissions, and there is no overlap between the calculation results of the selected models, the integrated model calculation result can be acquired by adding up the calculation result of the selected models.

- Time: April 2nd , 2010
- Location: Beijing, P.R. China
- Input Data Availability:
  - Home Power Consumption (Smart Meter)
  - Indoor Temperature (Built-in Thermometer of Portable Devices)
  - Indoor Humidity (Built-in Hydrometer of Portable Devices)
  - Outdoor Temperature (On-line Data Service)
  - Outdoor Humidity (On-line Data Service)
  - Car Model (User Given)
  - Car Travel Distance (Analyzed from GPS Data, GPS Data Acquired from Built-in GPS Receiver of Portable Devices)
  - IsDriving (Analyzed from GPS Data)

Figure 3 Sample User's Initial Settings for Carbon Footprint Calculation

Figure 4 depicts the process of offering carbon footprint calculation and mitigation suggestion in the system. After selecting the model set, a customized tree structure can be cut out from the original model registry tree structure. This customized structure could be used for saving the selected models, reserved parameters and calculation results. When the data is collected and sent to the system, the system will search the selected models' trigger restraints to identify which model should be activated for calculation. As shown in Figure 4, when one model is activated and gets a result, the result will also be added to the ancestry nodes of the current tree node. When the user would like to check his personal carbon footprint, he just needs to check the "Estimate GHG Emission" attribute of the customized tree structure's root node. By comparing the estimate GHG emission result of each tree node with the average value, the most carbon producer node and the largest carbon emitting activity could be identified and mitigation suggestions could be offered accordingly.

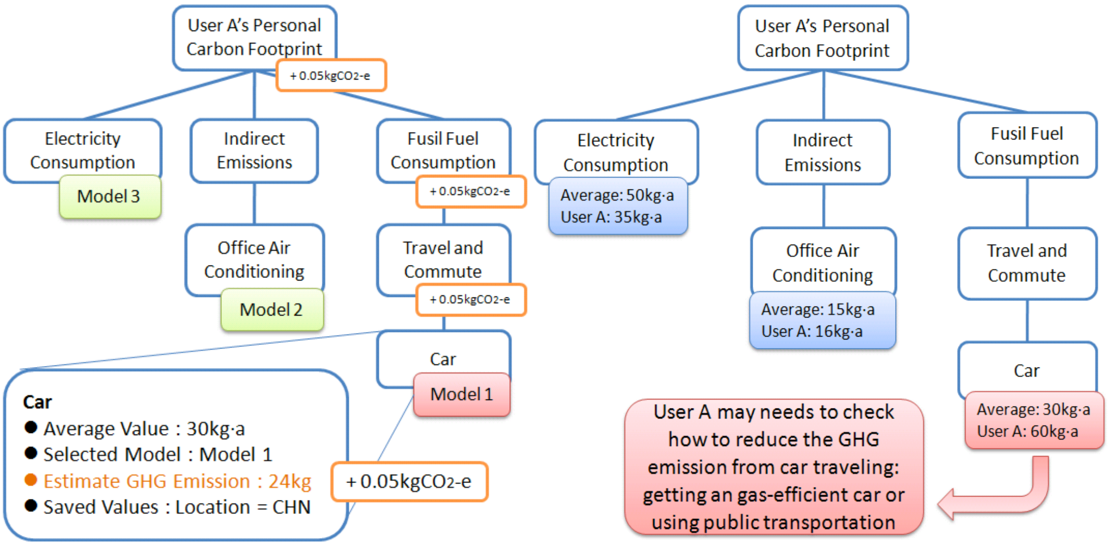

Figure 4 Carbon Footprint Calculation and Offering Mitigation Suggestions

3. Conclusion & Future Work

This paper has introduced our approach to building an open carbon footprint calculation platform for personal users. The platform uses a goal-based model registry, which is open for extension to manage the human activity-carbon emission quantitative models used for calculation. Besides, the platform also opens for on-line data and processed sensor data to be used for carbon footprint calculation.

As Figure 5 shows, we currently have a demo system under build. But to make the calculation platform work in the real world, an upper ontology for input data should be defined to make data transfer and sharing possible. In the future, we will study the existing portable sensor data and on-line climate data standard, to build a flexible and consistent data structure for the input data.

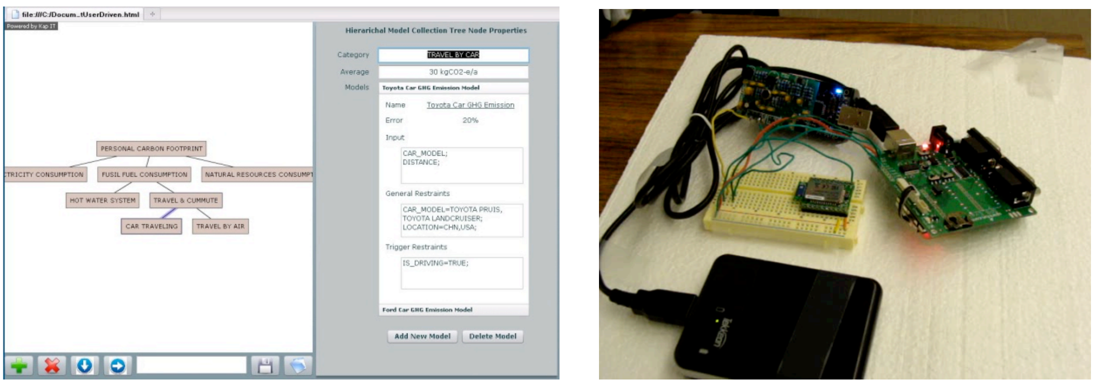

Figure 5 Software Interface and Sensor Network in the Demo System under Development

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