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学位の種類	博士(工学)
学位記番号	甲博理工第475号
学位授与年月日	平成26年3月25日
学位授与の要件	学位規則第4条第1項該当
学位論文題目	Development of GPS Assisted Online CO <sub>2</sub> -Temperature Mapping System (GPSを利用したCO <sub>2</sub> と気温のマッピングシステムの開発)
審査会	主査 湊 淳 委員 小澤 哲 委員 稲垣 照美 委員 桑原 祐史

## 論文内容の要旨

The objective of this research was to develop a global access method for accurate CO<sub>2</sub> density in certain points of the world.

The greenhouse effect is one of most potential deleterious impact of human race and all other species on earth. This is a very big concern on the scientific field as well as it seems to be a good reason even for changing governments, being a strong political issue today. Emerging of greenhouse gases as a result of uncontrolled development makes a world an unsuitable place to live for existences. It makes unstable climate conditions; by developing extreme weathering patterns, haze, smog like aerosols and retreat of glaciers which directs to rise of sea levels erases such small archipelagos, lowlands, islands of the world.

Gaseous constituents that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation are known as Greenhouse Gases (GHGs) (Scheutz et al., 2009). Most of world agreed and accepts that a human-induced increasing concentration of GHG in the atmosphere of the earth causes global climate change. Direct and indirect impacts of Industrialization such as fossil fuel burning etc., enhanced the emission of green house gases such as CO<sub>2</sub> after the 20<sup>th</sup> Century. As of January 2011, the level of atmospheric CO<sub>2</sub> is monitored as 391.19 ppm by volume. In 2009 January, it was 386.92, which monitored 4.27ppm has been grown within two years of period. It is very helpful to measure CO<sub>2</sub> level and temperature level with GPS information because it can easily map the both levels of a particular area.

GHG emissions from waste management contribute significantly to climate change (Chen and Lin, 2008; IPCC, 2007) and these emissions have therefore been identified as an important environmental concern in the waste sector (Liawsangan and Gheewala, 2008). Direct emissions of GHG from landfill systems are up to about 1000 kg CO<sub>2</sub>-eq per ton of waste (Manfredi et al., 2009). There is a growing interest in world to monitor such GHG as CO<sub>2</sub>, Methane etc. Among GHG, the CO<sub>2</sub> is most widely known greenhouse gas which enjoying 4<sup>th</sup> place among atmospheric gases and the first place among GHGs. CO<sub>2</sub> and the water vapour are main reasons to increase the greenhouse effect.

Move towards, a properly designed and managed online knowledge sharing system can improve the availability of real-time data around the world through internet among interested users of such data as researchers, students, decision makers etc. The data gathers by the sensing device stored in such knowledge sharing system called KISSEL which operated and maintained by Ibaraki University, Japan. Accessing to KISSEL (Knowledge Integrated Servers System for E-Learning), anyone can monitor certain existence co<sub>2</sub> levels and densities in the places where sensing devices (AIR-BOYs) are installed. A prototype has been developed for a versatile, flexible, cost efficient, and high speed Instrument to monitoring the CO<sub>2</sub> over Temperature. It helps to map co<sub>2</sub> data of a path such as roads, sea paths, and air ways below 18 km altitude or a

place for long time. The device is named as –AIR BOY–. This system is portable and easy to use.

The ultimate goal of the implementation of this system is to become a very useful tool in analyzing and isolating the geological areas of CO<sub>2</sub> mass production based on real measurements. The data collected and stored in this system alone can be used to analyze CO<sub>2</sub> concentrations against time, temperature, global coordinates or altitude. It utilizes an internal memory a CO<sub>2</sub> Sensor, temperature Sensor, a GPS+Altitude receiver, LCD Panel, a microcontroller and a USB-UART module with an Ethernet interface. Gathered data by the system, transmits to a database in a server called KISSEL a knowledge sharing system which mentioned earlier in this paper.

Gathered data transmitted from the sensing device to the database over internet by http GET request, with encapsulated data of its quarry string. In the end of the server side, it de-capsulate the quarry string in to data and stores it in the database. Then it mapped on a Google map according to a color code in respect of the density of CO<sub>2</sub> in each point. Equipment has been calibrated using an industrial calibrator made by data harvest Inc.

It should be noted that there are many previous studies have been done regarding CO<sub>2</sub> monitoring systems but no one can find a useful online real-time in-situ data of a certain point. (Ex, CO<sub>2</sub> level of Tokyo city, or Shanghai City at this moment) There is no this kind of developed and implemented on-line knowledge sharing system architecture of real time monitoring CO<sub>2</sub> can be found anywhere in internet and which the originality of this system is. This system can be deployed anywhere in the world whether internet connection is available or not. Once it connects to the internet, it starts to send the saved data to the KISSEL data base and update it. Power consumption is also very low of this module can simply operate using 1x1 feet solar panel. Internal rechargeable battery pack can store power to operate overnight. Taking In-Situ data of GHG can be very useful in industrial areas, and garbage dumps etc which cannot be taken using remote sensing method using satellite spectrum images. It is very useful for respective parties such as researchers and general public. In this study, it is gathered data in three countries, Srilanka, India and Japan, observed a higher level of CO<sub>2</sub> around industrial, urban areas than rural areas in all three countries. Temperature also was higher in such places than rural areas. Solar radiation and other visible light spectrums, easily comes through atmosphere in to the earth surface and makes it hot. The GHG traps infrared radiation, emits from the hot surfaces, inside atmosphere and re-radiated it makes environment hot. In COLOMBO - srilanka, and PUDUCHERRY of India displayed the highest amount of ppm of CO<sub>2</sub> and contaminated was COLOMBO the lowest amount enjoys in IBARAKI during the trial. However, multiple place monitoring in same time of the day in each region. This system can fix as many as possible in some industrial areas to gather data and share that data to the general public without any fee. Exposing this unknown data of GHG emissions free to public can give them an idea to force their respective community leaders, company owners, vehicle users to reduce the emission level of GHG to reduce the rise of climate change. This study demonstrates that system could make meaningful contributions to global climate-change mitigation by making its real-time sensed data available to public and other respective parties. It should be further developed by adding a good and solid body; a water resistant option should also be added.

## 論文審査の結果の要旨

本研究の目的は、特に教育者や学生が自由に使えるような、グローバルなCO<sub>2</sub>濃度計測およびアクセス方法を開発することにある。

地球の大気中の温室効果ガス濃度の人為的増加は地球規模の気候変動を引き起こすことが予測されている。温室効果は、人類と地球上のすべての生物に対する最も潜在的な有害な影響の一つである。2011年時点の大気中の二酸化炭素のレベルは体積濃度391ppmとされている。工場や農場などローカルなCO<sub>2</sub>排出量を見積もるためには、低コストで可動型の測定システムの利用が不可欠である。

本研究では、まず小型で、可搬、低コストの環境計測装置（AIR-BOY）を開発した。AIR-BOYは、マイクロコントローラ、内部メモリ、CO<sub>2</sub>センサ、温度センサ、GPSレシーバ、LCDパネル、イーサネットインターフェイス、USB-UARTモジュールから構成される。AIR-BOYは、GPS情報、CO<sub>2</sub>濃度および温度などを測定する。本装置を用いて道路、海上などの移動経路上にCO<sub>2</sub>濃度データをマップすることができる。消費電力は小さく、1フィートの太陽電池パネル1枚と内蔵充電式バッテリーパックで操作することができる。

さらに測定データをネットワークで監視するシステムを開発した。ネットワークの監視には、茨城大学の知識共有システムKISSEL (Knowledge Integrated Servers System for E-Learning)と呼ばれる統合サーバシステムを利用する。KISSELサーバを用いて、環境計測に関心がある教育者や学生のユーザーの間でインターネットを介してリアルタイムデータの共有、分析が可能となった。AIR-BOYの測定データは、HTTPでインターネット上のサーバに送信され、データベースに保存される。その後、各ポイントにおけるCO<sub>2</sub>濃度に対応した色コードに従ってGoogleマップ上にマッピングされる。開発した測定システムを用いてスリランカにおける評価実験をおこなった。

(判定) 申請者は、博士後期課程在学中に、必要な単位を取得し、第一著者の学術誌論文1編を発表している。GPS、マイクロコントローラとネットワーク技術を用い、南アジアなどの開発途上国における環境教育の利用も考慮して、計測からデータ利用まで開発及び検討を行ったことが学術的に高く評価できる点である。これらを総合して、当該研究は、博士(工学)の学位授与に値すると判定する。