ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

INTELLIGENT CYBER-PHYSICAL SYSTEM CONFIGURATION BASED ON MULTI-SENSOR TECHNOLOGY

Hao Yang*, Xiangyang Xu, LingFang Yin

* Jiangsu University of Science and Technology, Zhenjiang City, Jiangsu Province, P. R. China
Geodetic Institute, Leibniz University Hanover, Nienburger Str. 1, 30167, Hanover, Germany

DOI: 10.5281/zenodo.400856

ABSTRACT

In recent years, Cyber-physical system (CPS) becomes critical development direction in the academic and technological research. Carrying out research and application of CPS is of great significance to accelerate the development of industrialization and information fusion. The innovation of this paper is that an intelligent CPS with multi-sensor technology is proposed which are dominantly composited with 3D laser scanning and photogrammetry that can especially figure out the physical space with 3D point clouds and digital image. The smart CPS is a multidimensional intelligent technology system which deeply integrate the cyberspace and physical space through collection, analysis, evaluation, optimization, and coordination based on large-scale data, network and grid computing.

KEYWORDS: Multi-sensors, Smart Grid, Laser Scanner, Point Cloud, Cyber-physical system.

INTRODUCTION

A cyber-physical system (CPS) is a system with integrated computational and physical capabilities that can interact with humans through many new modalities [1]. It is a multidimensional complex system of integrated computing, network and physical environment, which realizes real-time sensing, dynamic control and information service of large engineering system through the organic integration and deep cooperation of computation, communication and control technology. CPS implements calculation, communication and physical system integration design, which can be more reliable, efficient, real-time collaboration, and has important and broad application prospects. In recent years, CPS becomes a critical development direction in the academic and technological research. Carrying out research and application of CPS is of great significance to accelerate the development of industrialization and information fusion.

CPS system is a united system which is based on and requires improvement of each unit for the function of the joint system. From the networking side, rebuilding of computing and networking abstractions is important to embrace physical dynamics and computation in a unified way in order to realize the full potential of CPS [2]. [3] raised the innovation of software-intensive embedded systems with the global digital networks. The design, construction and verification of CPS pose a multitude of technical challenges that must be addressed by a cross-disciplinary community of researchers and educators [4].

Many grand challenges await in the economically vital domains of transportation, health-care, manufacturing, agriculture, energy, defense, aerospace and buildings. CPS is beneficial for many application fields. For example, [5] investigated the cyber-physical controls required to support the smart grid and the communication and computations that must be protected from cyber-attack in electric power management. [6] studied a networked unmanned air vehicles (UAVs) using the theory of CPS and provided effective solution for model-based fully automated software synthesis and high-fidelity performance analysis.

Geodetic measurements especially with 3D terrestrial laser scanning (TLS) has a good prospect due to it can efficiently map 3D information of the whole object surface. The benefit of TLS is also evident with combination to numerical models such as finite element method (FEM) models, which allows the prediction and monitoring of deformation behavior of objects [7-11]. Multi-sensor system realizes the function of accurate and real-time

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

information collection of 3D position and coordinates, which contains TLS, digital camera, laser tracker, GPS, displacement sensors, and etc. Integrating multi-sensor system and numerical FEM model, a complete system for health monitoring of structures can be built with CPS, which emphasize real time information, computation and human-computer interaction.

DISCUSSION

This paper focuses on the CPS-based intelligent monitoring and management system which is capable to acquire and map 3D information of objects, analyze automatically the information, offer interaction with human, and give an assessment and instructions to the current situation. Applying this system in our city management, a digital and smart physical space will be built, which will save many manpower, material and financial resources, e.g. in urban construction, monitoring and repairing of buildings, transportation and facilities, configuration and management of information and resources, space recognition, positioning and track system and the related automotive service it can brought, and etc.

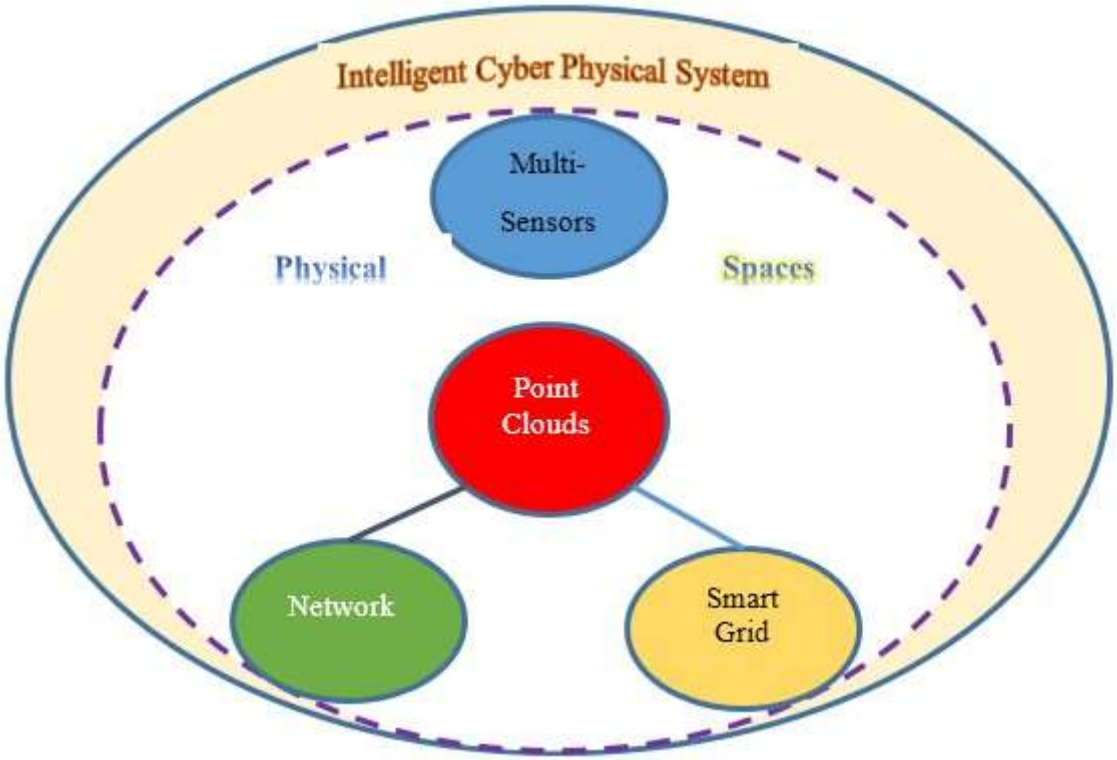

Fig. 1 Framework of intelligent CPS

As described in [12], the CPS function with smart connection, conversion, cyber, cognition and configuration level. This paper proposes an intelligent CPS model which integrated the original CPS and smart physics space. The systematic configuration of the intelligent CPS model is presented in Fig. 2. The system contains multi-sensors for data collection, data processor unit for data calculation and prediction, system power, mobile terminal, network and intelligent core which is composed by control center, configure unit and smart grid in order to analysis and allocate instructions according to feedback of other units.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

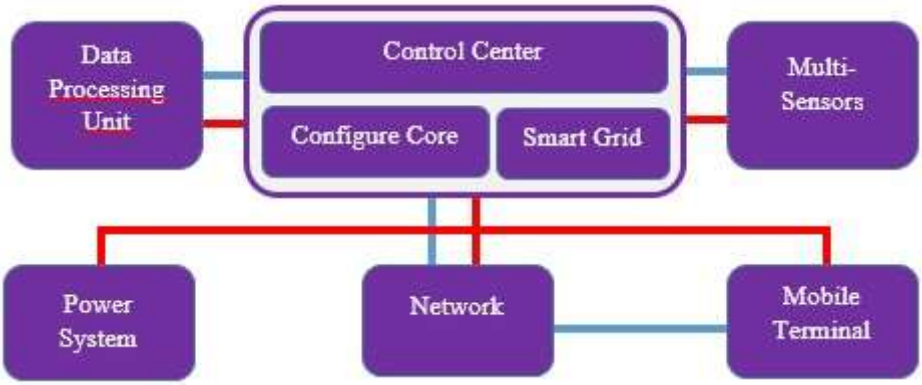

Fig. 2 Systematic configuration of intelligent CPS

The intelligent CPS model can be widely applied in the fields of aerospace, civil engineering, automotive, health care, transportation and etc. The workflow of the system is shown in Fig. 3, where multi-sensors collects data such as point clouds, digital images, and etc., then the data flow is stored in smart grid and configured through process control system.

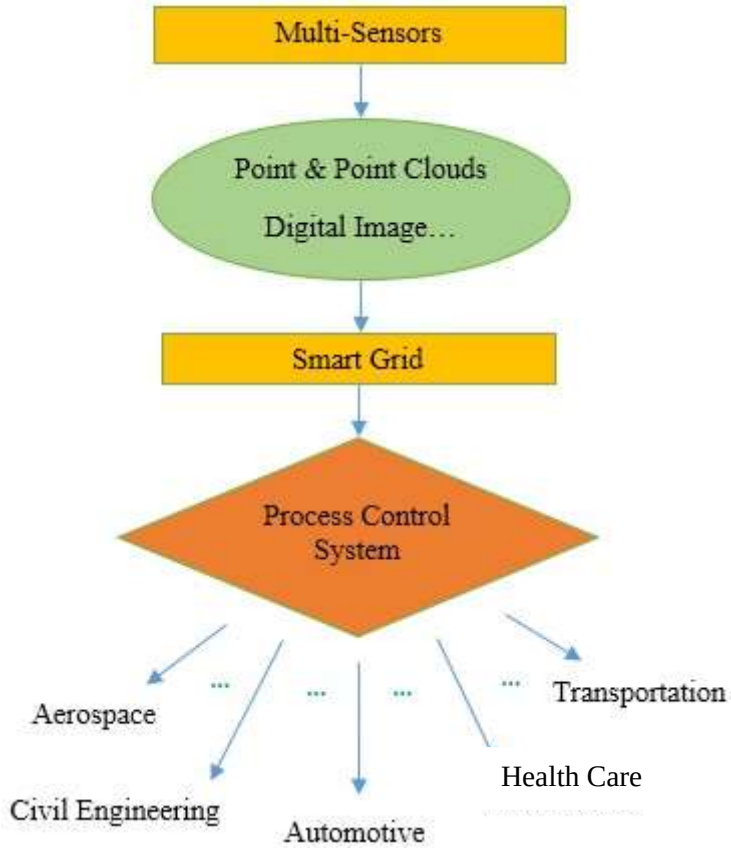

Fig. 3 Workflow of intelligent CPS

CONCLUSION

This paper proposes and describes an intelligent CPS with multi-sensor technology which can configure the physical space with 3D point clouds and digital image. A new sight is rise up with the integration of the intelligent CPS and the smart city though 3D point cloud data. It is possible to configure the physical space, which is the common of the intelligent CPS and the smart city, with the spatial multi-dimensional information. Moreover, on the configuration level both the intelligent CPS and the smart city requires self-configure for resilience, self-adjust for variation and self-optimize for disturbance.

ISSN: 2277-9655
Impact Factor: 4.116
CODEN: IJESS7

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

The authors also would like to acknowledge the support of Natural Science Foundation of Jiangsu Province (No: BK20160558).

REFERENCES

[1] US National Science Foundation, Cyber-Physical Systems (CPS)
[2] Edward A. Lee. Cyber Physical Systems: Design Challenges. 11th IEEE Symposium on Object Oriented Real-Time Distributed Computing (ISORC).
[3] M. Broy. Cyber-physical systems: Innovation durch softwareintensive eingebettete Systeme. Springer-Verlag, 2011
[4] R. Rajkumar, I. Lee, L. Sha and J. Stankovic. Cyber-Physical Systems: The Next Computing Revolution. Proceedings of the 47th Design Automation Conference, California, June 13-18, 2010.
[5] S. Sridhar, A. Hahn, and M. Govindarasu. Cyber–Physical System Security for the Electric Power Grid. Proceedings of the IEEE, Vol. 100, No. 1, January 2012.
[6] J. Sztipanovits, X. Koutsoukos, G. Karsai, N. Kottenstette, P. Antsaklis, V. Gupta, B. Goodwine, J. Baras and S. Wang. Toward a Science of Cyber-Physical System Integration. Proceedings of the IEEE 100.1, 2011.
[7] Yang, H.; Omidalizarandi, M.; Xu, X.; Neumann, I. (2016): Terrestrial laser scanning technology for deformation monitoring and surface modeling of arch structures, In: Journal of Composite Structure 2016.
[8] Yang, H.; Xu, X.; Neumann, I. (2016): Laser Scanning-Based Updating of a Finite Element Model for Structural Health Monitoring, In: Sensors Journal, IEEE.
[9] Yang, H.; Xu, X.; Neumann, I. (2016): Optimal finite element model with response surface methodology for concrete structures based on Terrestrial Laser Scanning technology, In: Journal of Composite Structures 2016.
[10] Yang, H.; Xu, X. and Neumann, I. (2014): The Benefit of 3D Laser Scanning Technology in the Generation and Calibration of FEM Models for Health Assessment of Concrete Structures, In: Sensors, Vol. 14, No. 11, 21889-21904.
[11] Xu, X.Y.; Yang, H.; Neumann, I. (2015): The Benefit of TLS in the Generation and Calibration of FEM Models for Health Assessment of Concrete Structures, Geodetic Week 2015, Stuttgart, Germany.
[12] J. Lee, B. Bagheri and H. Kao. A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems. Manufacturing Letters. 3, 18–23.