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IDEA OF PARAMETRIC AND SEMANTIC OPEN PLATFORM SMART DEVICES SENSOR

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Abstract. *The parametric and semantic model of open platform of intelligent devices and sensor technologies based on tomography in cyber-physical self-monitoring system contains: new techniques of conducting measurements and construction of novel intelligent measurement devices, system's structure along with communication interface, unique algorithms for data optimization and analysis, algorithms for image reconstruction and technological processes monitoring, cyber-physical system's prototype.*

Keywords: process tomography, artificial intelligence, sensors

KONCEPCJA PARAMETRYCZNO-SEMANTYCZNEJ OTWARTEJ PLATFORMY INTELIGENTNYCH URZĄDZEŃ SENSOROWYCH

Streszczenie. *Parametryczno-semantyczny model otwartej platformy inteligentnych urządzeń sensorowych został oparty na technologiach tomograficznych. W samo-monitorującym się systemie cyber-fizycznym zastosowano nowe techniki pomiarowe i konstrukcje inteligentnych urządzeń pomiarowych. Proponowane rozwiązanie prototypu systemu cyber-fizycznego składa się z interfejsu komunikacyjnego, unikalnych algorytmów do optymalizacji i analizy danych oraz systemu monitoringu procesów logistyczno-technologicznych.*

Słowa kluczowe: tomografia procesowa, sztuczna inteligencja, sensory

Introduction

In this work there was presented the idea of creating a platform for intelligent enterprise architecture open freely configurable and cooperation with external systems.
The system consists of the following components:

- New measurement techniques and design innovative smart metering devices.
- System structure and communication interface.
- New unique algorithms for optimization and data analysis.
- Algorithms for image reconstruction and monitoring processes, logistics and technology.
- The prototype cyber-physical platform.

The platform will be enable to manage the intelligent structure of the companies in terms of processes, products, simulation and virtual products. This will enable the optimization and auto-optimization of design processes, logistics and production. There will allow to track product cycle and provide for collaboration with external applications. The system will operate autonomously, monitoring, controlling, performing measurements and gathering the results. The collected data can be easily visualized. In addition, they will be used to create a unique knowledge base and will support the expert system [1, 3, 5, 13]. Systems based on tomography and solving the inverse problem for inaccessible areas are developed over many years [2, 4, 6–12, 14–21].

1. Platform

The proposed solution consists of the following components (Fig. 1):

I. The device monitoring and measuring
The measuring device will be responsible for data acquisition of sensors, pre-processing and transmission to the system server-web. Additionally, the system allows remote calibration of the sensors as well as monitoring and conditioning equipment manufacturing (Fig. 4-7 and Fig. 8-9).

II. The web-server with the client mobile
The measurement data will be stored on the server. A user from anywhere in the world will be able to manage the data collected through the portal and external systems. The collected data can be plainly visualized (Fig. 2).

III. Portal (Communication Platform)
Portal will allow the user to manage data stored on the server and will have elements such as orders, production orders, deliveries, invoices, statements, complaints virtual product (Fig. 3).

IV. External systems (communication platform)
This element will include interfaces for data exchange with the systems of customers and suppliers. Information on the state of cooperation will be available to suppliers from anywhere in the world thanks to cooperation with any external computer system.

V. Internal systems (communication platform)
Data exchange interface enables the cooperation of internal enterprise system, in which are recorded the economic processes of the server-platform web-based. For processes in which the information will be exchanged, among others: service purchases and sales, in accounting or personnel management.

VI. Expert System (module algorithmic analysis)
Expert system will be possible to optimize processes within the technology based on the knowledge base and data from sensors measuring.

VII. Automation and individualization of production (kernel)
The system based on the measurement data will assist the manufacturing process at each of its steps (automation and optimization).

VIII. Virtual product (Communication Platform)
Virtual product will be innovative and unique element of the system. The user will be able to individually design (select items) of the finished product. This element will enable the visualization of 2D and 3D product.

IX. Big data (kernel)
Base encyclopedic knowledge (experts), based on data from the measurement sensors and data provided by the users themselves (virtual product) will create a unique structure used in intelligent management.

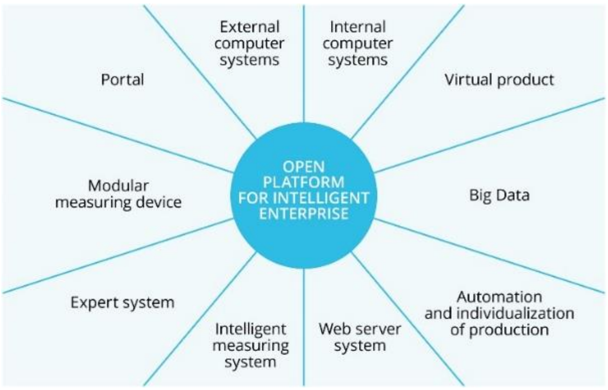

Fig. 1. The Idea of the system

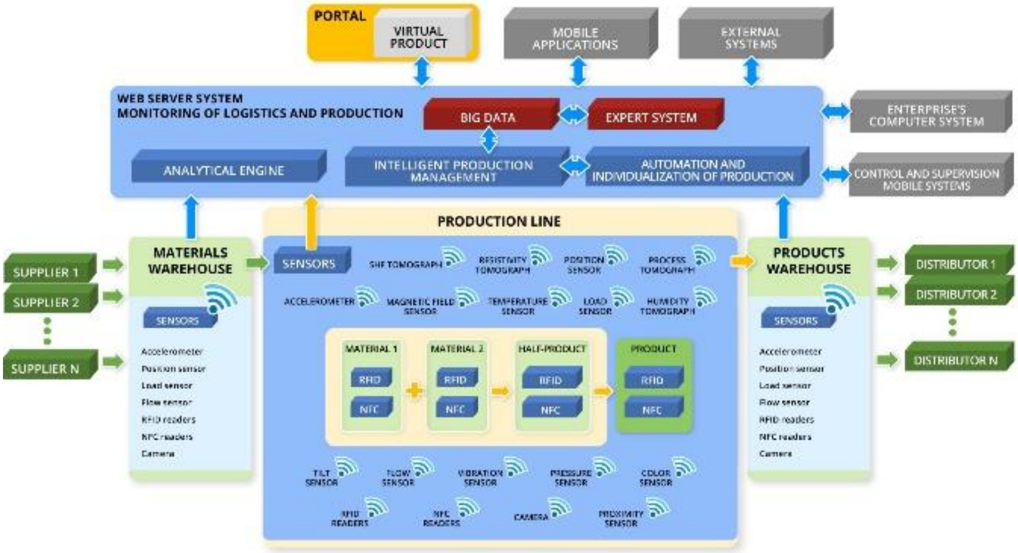

Fig. 2. System's functional model

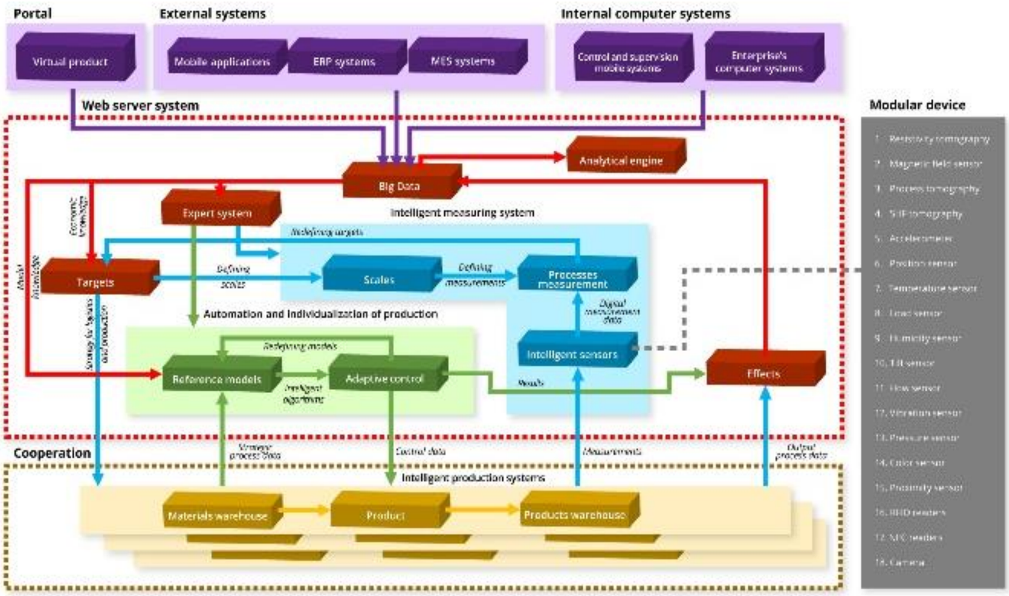

Fig. 3. System's process model

2. Devices

The platform will be communicated to measuring data acquisition and controlling devices and systems, such as: the smart ECT device (Fig. 4), the flow control system (Fig. 5), production lines, EIT device (Fig. 6), the hybrid ET device (Fig. 7), intelligent sensor devices (Fig. 8 and 9) and the multi-module device (Fig. 10).

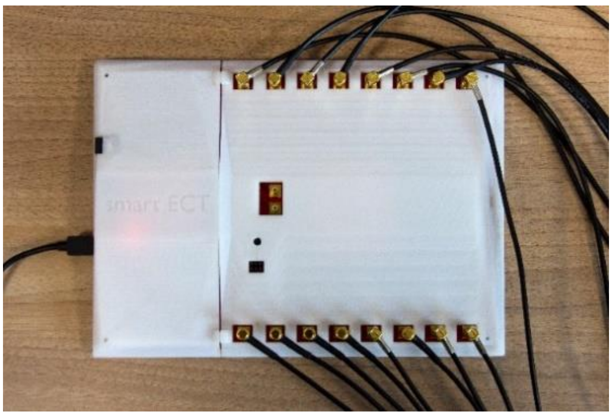

Fig. 4. Smart ECT device

Fig. 5. The main module of the system flow, where microprocessors control measurements

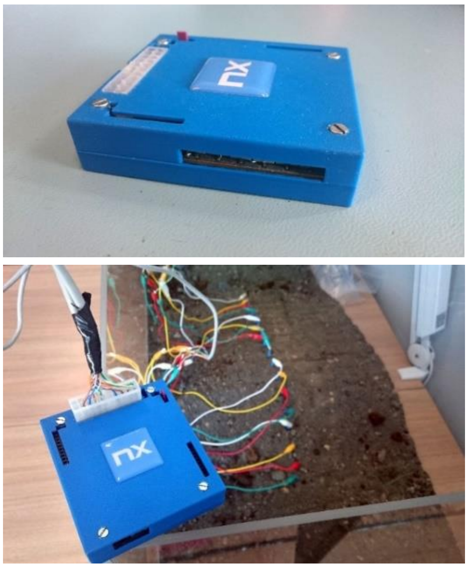

Fig. 6. EIT device

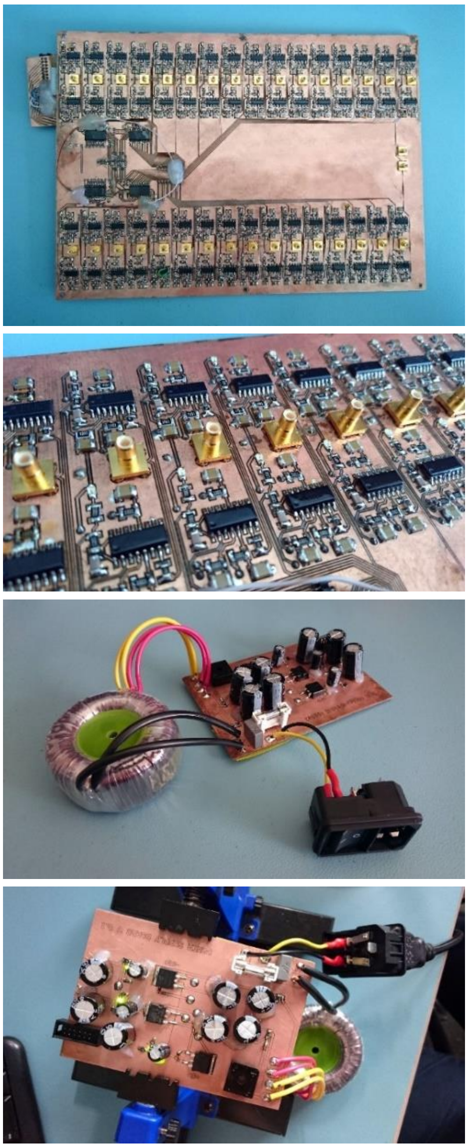

Fig. 7. The project of hybrid electrical tomography device (multiplexer and power supply)

3. Prototype sensor device

A prototype of a multi-module device is based on a multi-module measuring device (Fig. 10). Intelligent components measuring devices are the following: electrical tomography, sensor magnetic field tomography process tomography SHF, acceleration sensor, position sensor, temperature sensor, pressure sensor, humidity sensor, tilt sensor, flow sensor, vibration sensor, pressure sensor, color sensor, proximity sensors, RFID and NFC sensors.

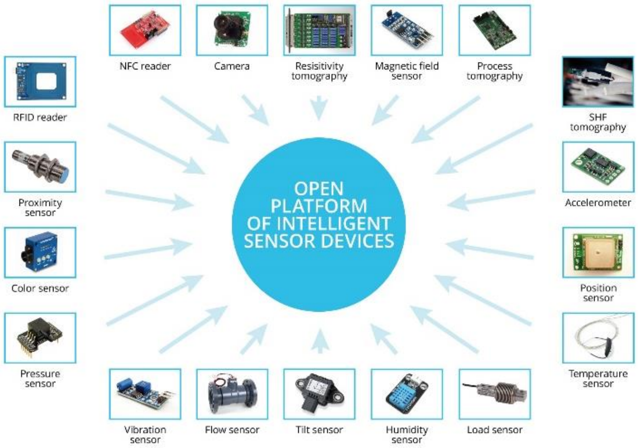

Fig. 8. The open platform of intelligent sensor devices

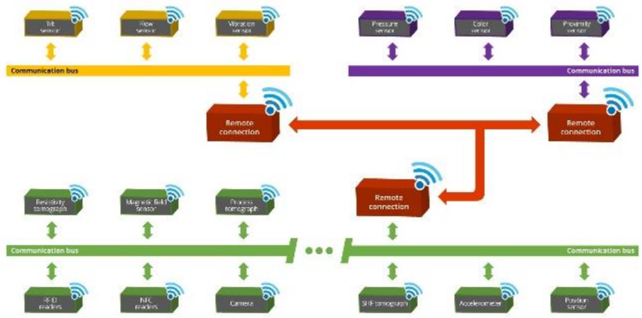

Fig. 9. System architecture of sensors devices

Fig. 10. Multi-module device

4. Results

The reconstructed data can be presented in graphical form using a graphical presentation of the data. The following figures show the reconstructed models and measurement data.

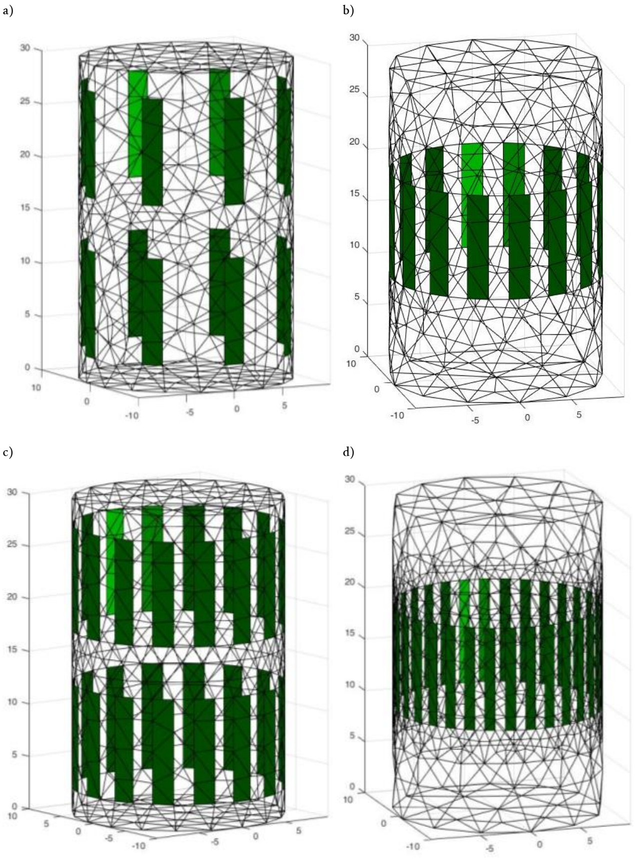

Fig. 11. Models of probes: a) 2×8 electrodes, b) 16 electrodes, c) 2×16 electrodes, d) 32 electrodes

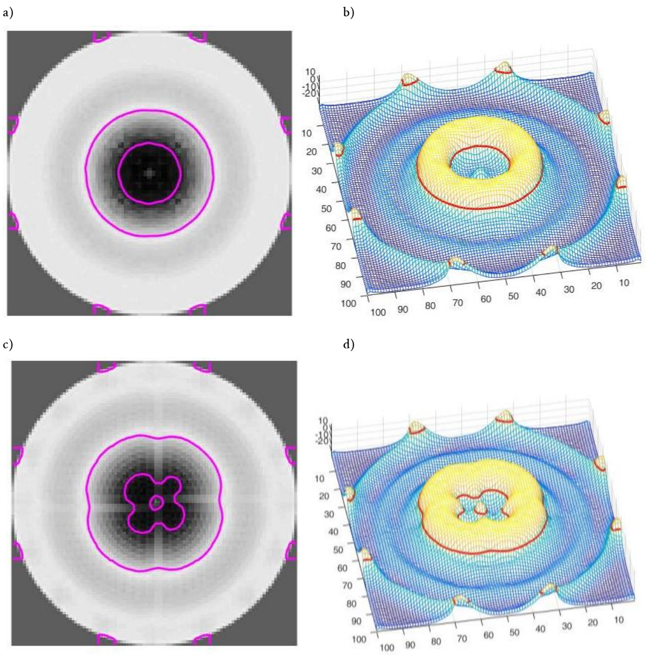

Fig. 12. Segmentation by the level set method

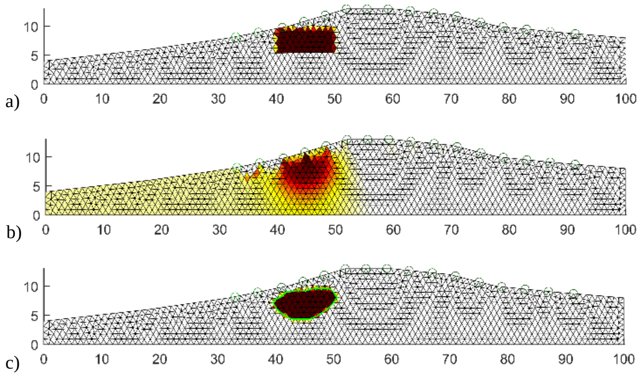

Fig. 13. The geometrical model I of the investigated flood embankment with 16 electrodes: a) the initial model, b) the reconstructed by Gauss-Newton method, c) the reconstructed by the level set method

Figure 11 show models of the different number probes: (a) 2×8 electrodes, (b) 16 electrodes, (c) 2×16 electrodes, (d) 32 electrodes. The segmentation flow by the level set method is presented in Figure 12. Figure 13 shows the geometrical model I of the investigated flood embankment with 16 electrodes, where (a) the initial model, (b) the reconstructed by Gauss-Newton method, (c) the reconstructed by the level set method. The objective function for this problem presents Figure 14.

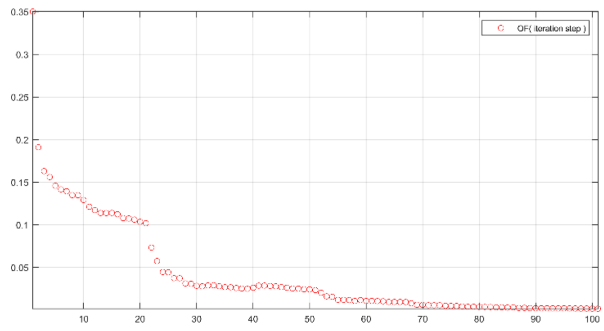

Fig. 14. The objective function for the model in Figure 13

5. Conclusion

The solution model of open platform of intelligent devices and sensor is based on technology tomographic and sensor networks. This system includes new measurement techniques and designs innovative smart measuring devices. The application structure covers a communication interface, unique algorithms for optimization and data analysis algorithms for image reconstruction and process monitoring.

References

[1] Beck M.S.: Process Tomography: Principles, Techniques and Applications, Elsevier Science 1995.

[2] Chen C., Wozniak P., Romanowski A., Obaid M., Jaworski T., Kucharski J., Grudzien K., Zhao S., Fjeld M.: Using Crowdsourcing for Scientific Analysis of Industrial Tomographic Images, ACM Transactions on Intelligent Systems and Technology (TIST),Vol. 7, 4, Article 52, 2016, [DOI: 10.1145/2897370].

[3] Filipowicz S.F., Rymarczyk T.: Tomografia impedancyjna, pomiary, konstrukcje i metody tworzenia obrazu, BEL Studio, Warszawa 2003.

[4] Kapusta P., Majchrowicz M., Sankowski D., Jackowska-Strumiłło L., Banasiak R.: Distributed multi-node, multi-GPU, heterogeneous system for 3D image reconstruction in Electrical Capacitance Tomography – network performance and application analysis. Przegląd Elektrotechniczny, Vol. 89, No. 2b, 2013, 339–342.

[5] Mosorov V.: A method of transit time measurement using twin plane electrical tomography, Measurement Science and Technology, v17, 4, 2006, 753–760.

[6] Musharavati F.: Process Planning Optimization in Reconfigurable Manufacturing Systems, Universal-Publishers 2010.

[7] Panczyk M., Sikora J.: A New imaging Algorithm for Electric Capacitance Tomography, Prace Instytutu Elektrotechniki, LXIII, Issue 274, 2016.

[8] Rymarczyk T.: New Methods to Determine Moisture Areas by Electrical Impedance Tomography, International Journal of Applied Electromagnetics and Mechanics 08/2016, 1-9, [DOI:10.3233/JAE-16207].

[9] Rymarczyk T., Filipowicz S.F.: The Shape Reconstruction of Unknown Objects for Inverse Problems, Electrical Review, NR 5, 3a, 2012.

[10] Rymarczyk T.: Characterization of the shape of unknown objects by inverse numerical methods, Przegląd Elektrotechniczny, R. 88 NR 7b/2012, 138–140.
[11] Rymarczyk T., Filipowicz S.F., Sikora J., Polakowski K.: A piecewise-constant minimal partition problem in the image reconstruction, Przegląd Elektrotechniczny, R. 85 NR 12/2009, 141–143.
[12] Sankowski D., Sikora J.: Electrical capacitance tomography: Theoretical basis and applications, Wydawnictwo Książkowe Instytutu Elektrotechniki, Warszawa 2010.
[13] Saravanan R.: Manufacturing Optimization through Intelligent Techniques, CRC Press 2006.
[14] Sikora J., Wójtowicz S.: Industrial and Biological Tomography: Theoretical Basis and Applications, Wydawnictwo IEL, Warszawa 2010.
[15] Sikora J.: Numeryczne metody rozwiązywania zagadnień brzegowych: Podstawy metody elementów skończonych i metody elementów brzegowych, Wydawnictwa Politechniki Lubelskiej, 2008, 2012, 2016.
[16] Smolik W., Radomski D.: Performance evaluation of the iterative image reconstruction algorithm with sensitivity matrix updating based on real measurements for electrical capacitance tomography, Meas. Sci. Technol. Vol. 20, No. 11, 2009, 115502.
[17] Smolik W.T., Szabatin R.: Non-invasive imaging of dynamic processes in ir-Lift chemical reactor using elextrical capacitance tomograph, 4th International Workshop on Process Tomography (IWPT-4), Chengdu, China, September 21-22, 2011.
[18] Smolik W., Kryszyn J., Radzik B., Stosio M., Wróblewski P., Wanta D., Dańko Ł., Olszewski T., Szabatin R.: Single Shot High Voltage Circuit for Electrical Capacitance Tomography, Meas. Sci. Technol., 2017.
[19] Smolik W, Forward Problem Solver for Image Reconstruction by Nonlinear Optimization in Electrical Capacitance Tomography, Flow Measurement and Instrumentation, Vol. 21, Issue 1, 2010, 70–77.
[20] Wajman R., Fiderek P., Fidos H., Jaworski T., Nowakowski J., Sankowski D., Banasiak R.: Metrological evaluation of a 3D electrical capacitance tomography measurement system for two-phase flow fraction determination; Meas. Sci. Technol., Vol. 24, 2013, No. 065302.
[21] Wang M.: Industrial Tomography: Systems and Applications, Elsevier 2015.

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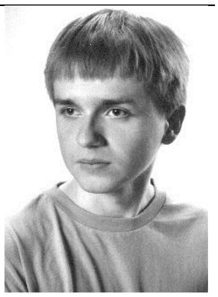

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