Augmented Reality for Interactive Physical Field Visualization

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Abstract— *In this work is presented a sophisticated computer aided system for augmented reality generation. The system is applicable for advanced field data visualization activities such as non-destructive testing and examination; industrial testing and inspection; biomagnetics; educational activities, etc. This system makes possible combination of different data sources in one virtual reality environment that can be used for simultaneous dynamic visualization. This type of integrated visualization systems allows engineering problems to be visualized and analyzed more effectively and to acquire closer interaction in the process with the observer.*

***Keywords*— augmented reality, visualization, data fusion, field measurements.**

I. INTRODUCTION

Augmented Reality is a fast emerging visualization technology which could take place in all kinds of human activity. It could be defined as a real-time view of a physical world environment that has been enhanced or augmented by adding virtual computer-generated information over it [1]. Augmented Reality as technology has the potential to influence significantly not only the communication and entertainment applications, but also practically all data visualization means in industry and science [1-5].

In this paper we are presenting a computer aided system for Augmented Reality generation. The system is applicable for advanced observations in field data visualization activities such as non-destructive testing and examination; industrial testing and inspection; electromagnetics and biomagnetics; education, etc. This system makes possible combination of different data sources in one virtual reality world that can be used for simultaneous dynamic visualization.

Many physical fields such as thermal, electromagnetic, mechanical can be measured and visualized over a video stream, generated by virtual reality engine.

II. AUGMENTED REALITY VISUALIZATION SYSTEM ARCHITECTURE

The main task of the proposed system is to perform an effective visualization, combining multi-physical field data with 3D quality video stream in close to real-time mode. The augmented effect is related with the ability to observe the components of physical field (e.g. field intensities, flux densities, field gradients, temperatures, etc.) over the inspected object or even inside its volume. Primary fields included are electric, magnetic and thermal fields due to presence of fast and reliable solver engines for them. The parallel reality system architecture is shown in Fig.1. System contains: Input devices that acquire data from the real world, virtual reality processing kernel and output visualization devises.

Input devices are: measuring physical field data from the real world; perform video stream capture; position/orientation data for quality visualization overlapping. Most often those are video camera device or pair of cameras, automatic field measurement devices or even sensor networks that can collect necessary data to parallel reality system processor and position/orientation sensors.

Dynamically collected data is segmented and translated to virtual reality 3D kernel. System kernel is VRML based [4, 5]. System kernel can use also data from field analysis block- data solver, which provides reconstructed or calculated field visualization pictures.

Output devises must allow coordination of the human operator behavior with virtual reality engine and most important close and realistic visualization for the system user. [1-3]

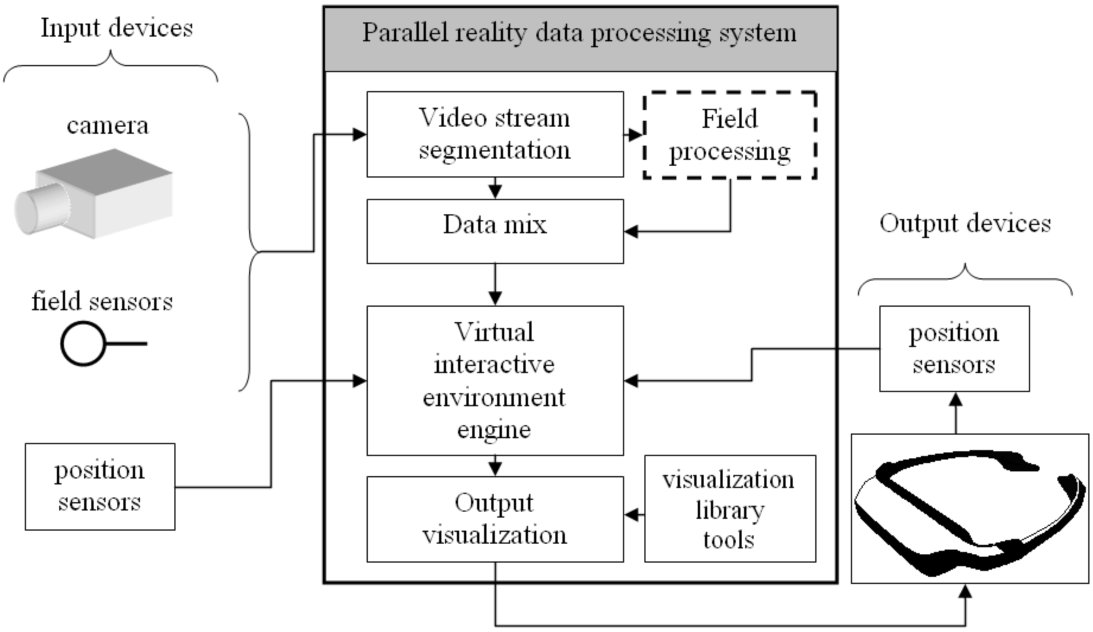


FIG.1 AUGMENTED REALITY SYSTEM BLOCK SCHEME

This system makes possible combination of different data sources in one virtual reality environment that can be used for simultaneous dynamic visualization.

III. MAGNETIC FIELD IMAGING ARRAYS

Here are presented specially designed magnetic field sensor arrays capable to forma a real-time spatial image.

Sensor array design depends largely upon the specific application. Arrays can include two- and three-axis magnetic sensors to measure vector fields. They can be configured as extended one-dimensional arrays to survey a wide area in a single pass. Two-dimensional arrays of sensors can be left in place to survey an area without moving the array.

The design of a two-dimensional array with 9 sensors is shown in Fig. 2. Each sensor is a single integral Hall's effect or magneto-resistive sensor (MR). They are connected in parallel with a common supply and ground. An example of a two-dimensional array of seven sensors is shown in Fig. 4.

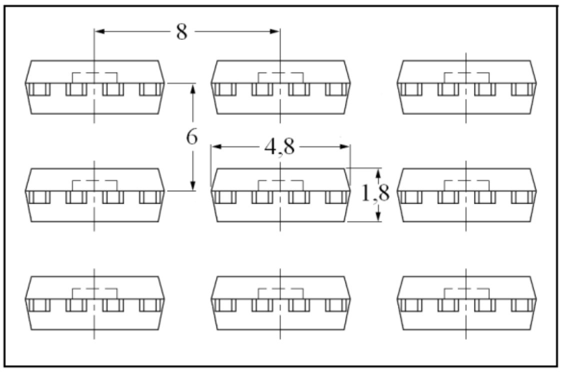


FIG.2. 3X3-ELEMENT SQUARE ARRAY

This array can assure direct magnetic field image as well as field gradient in XZ plane [8]. The total width of both arrays is 16 mm and the length is 22 mm. They are detecting the vertical component (y) of the magnetic field.

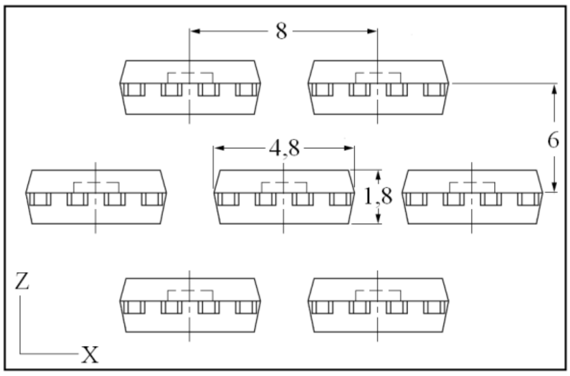


FIG.3. 7-ELEMENT HEXAGONAL ARRAY

IV. MAGNETIC FIELD SOLVER AND VISUALIZATION

Measured magnetic field data by sensor arrays could be used for field source reconstruction calculations, before visualizing it into the video stream. [6-8]

Magnetic flux density caused by 3D source in linear homogenous media could be calculated by the Biot-Savart law (1).

$$B_y(x,y,z) = \frac{\mu_0}{4\pi}\int_{\Omega}\frac{J}{r^2}d\Omega \tag{1}$$

Where B_y is the magnetic flux density y-component in (x, y, z) position around the field source; r - distance vector between measurement sensor position and the source; J - source current density; Ω - area of interest.

Biot-Savart solver is simple and relatively fast method both for program realization and implementation.

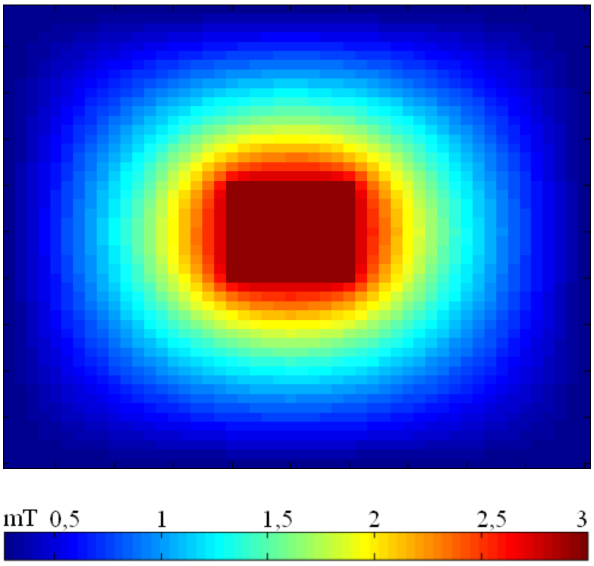
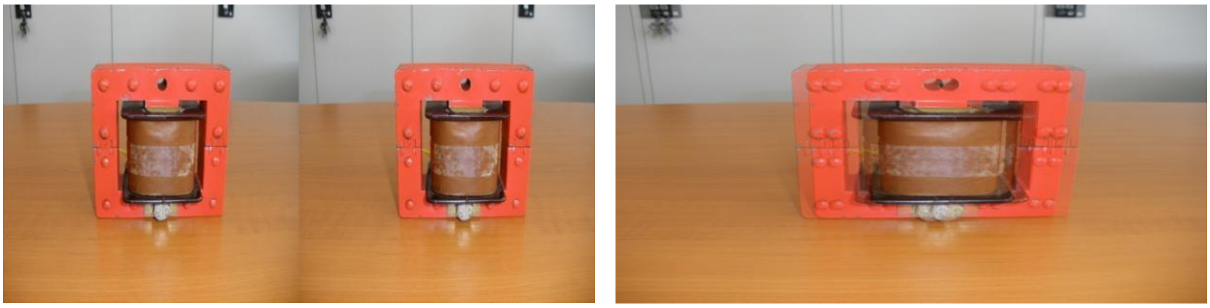


FIG.4. CALCULATED FIELD DISTRIBUTION

Direct user visualization and interaction is performed by VUZIX WRAP 1200 VR glasses [9].

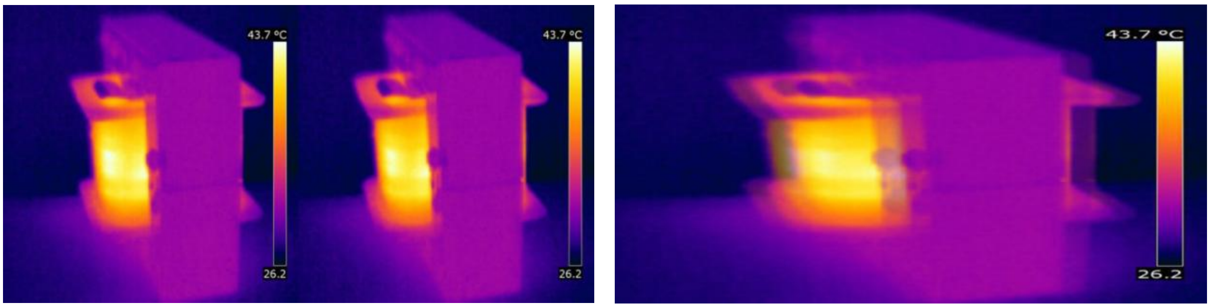
V. RESULTS

Augmented reality technology is demonstrated over an electromagnetic actuator device (Fig.5-a). Obtained visualizations are acquired by four independent 3D channels. For each channel are presented separate composite images for left and right eye, produced by the visualization system kernel.



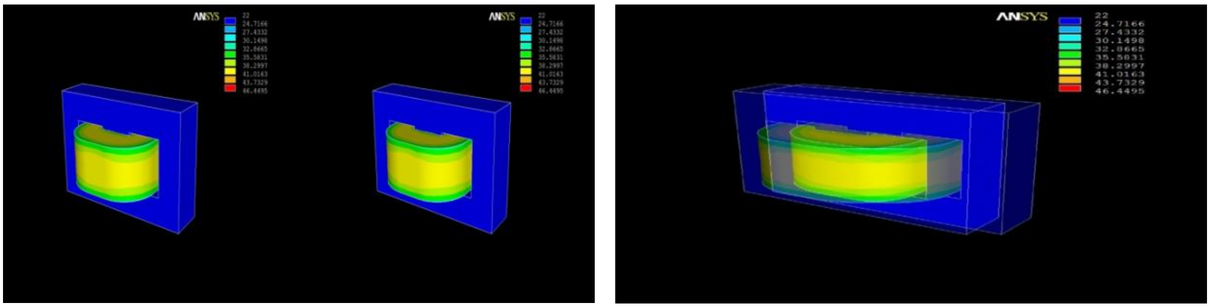
(A) (B)

FIG.5. OPTICAL CHANNEL



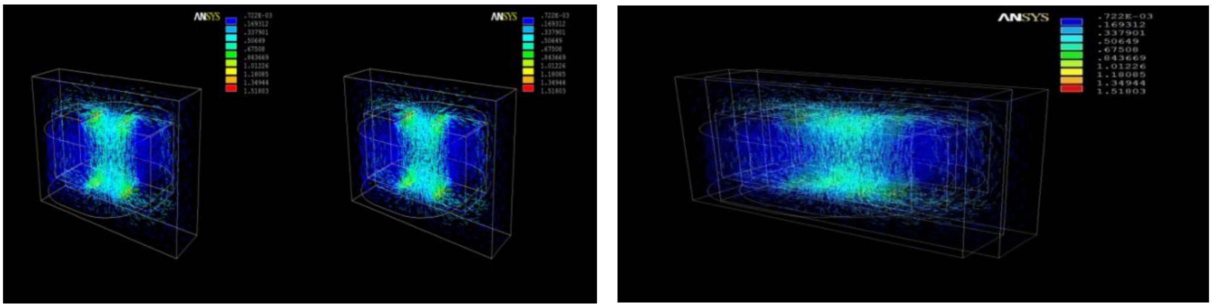
(A) (B)

FIG.6. THERMAL FIELD DISTRIBUTION ACQUIRED BY INFRARED CAMERA



(A) (B)

FIG.7. CALCULATED MAGNETIC FLUX DENSITY DISTRIBUTION



(A) (B)

FIG.8. MAGNETIC FLUX DENSITY VECTOR DISTRIBUTION

Two external measuring devises are used to acquire measurement data: onboard cameras of VUZIX WRAP 1200 VR glasses [9] and FLIR thermo-vision camera [10]. Also computational output from ANSYS Mechanical FEA software is provided through VRML output [11].

On Fig.5 is shown the optical visualization channel, provided by the pair of optical VR cameras. Fig.5-a represents the separate images for left and right eye correspondingly. On Fig.5-b is presented the composite 3D image viewed by the user. On Fig.6 is shown the infrared visualization channel, provided by FLIR thermo-vision camera [10]. On Fig.7 is presented magnetic flux density distribution of the electromagnetic actuator. On Fig.8 are shown the magnetic flux density vector distribution. Reconstructed field distribution inside the magnetic core is calculated by ANSYS [11].

VI. CONCLUSION

The proposed system allows the integration of various data collection methods types, e.g. imaging sensors and systems for magnetic, thermal and electric fields. It supports also the integration of an additional analytic component, called field calculator, into this complex virtual environment. Data fusion algorithms could be performed to create optimal visualization pattern for the user. The system is applicable for advanced field data visualization activities such as non-destructive testing and examination; industrial testing and inspection; biomagnetics; educational activities, etc. This type of integrated visualization tools and devices allows engineering systems to be visualized and analyzed more effectively in brand new observation level.

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