

# Visualization of Manufacturing Composite Lay-up Technology by Augmented Reality Application

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*Abstract:* - This paper presents possibilities of composite assembling process visualization by using special tools of the Augmented Reality (AR) and logical procedures from related areas such as a Computer Aided Design and Manufacturing. These possibilities are implemented in the virtual assembling environment of AR, where engineers and designers can see important visual information about an exact position and orientation of the single composite element that creates a part of the entire composite assembly. By means of this the application of the AR allows customer to visualize and see the moving process of single composite layer according its trajectory and prevents the mistakes in the assembling processes.

*Key-Words:* - Augmented Reality, logical loops, composite layers, Lay-up (manual)

## 1 Introduction

This paper approaches basic problems and structural logical elements of the essential section of the Augmented Reality (AR), which is understood as visualization process where real environment is covered by virtual one and from the viewpoint of its user together they, present one working space. The main idea of the AR and basic process algorithms are explained by means of concrete examples in the particular points of this contribution. After general expressions it provides the information about advances of composite assembling cycle visualization that brings science view into area of these problems. Such information is necessary and needy for engineering tasks of the designer in the difficult processes of creation of the composite structure. The entire structure of this article is focused on the characterization of steps that follow each other while describing information flow between logical blocks which create general connection for the AR.

The first part of the paper deals with data which concern application environment where the mentioned AR was created. This part comprises important information about special visual virtual tools which were applied during the creation of this application. By using these tools, the application allows for designer to manage an entire data flow between different logical cores of the application. The next parts provides the exact view on the single

logical areas where the necessary data are harvested and compared with values from virtual arrays and then they are sent to the displaying section of the AR. After that, the article deals with solutions for the AR application of composite process visualization where the designer is able to see the process of the moving of the particular composite ply according the applying trajectory and the final position for all composite layers with their own boundary edges. Final part of the article is focused on the special programming packet and improving elements which increase entire quality of the visual area of the AR.

As mention before, an augmented reality system generates a complex view for the user. It is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. Thanks to its possibilities it finds the utilization in many industrial areas [1].

## 2 Augmented Reality Visualization

During the process of the composite layers application designer stands before many problems and their results have a strong influence to the final conditions of composite structure. In the first phase of creation of the composite construction the single composite layers must be defined by using of special composite modules which are implemented

in the logical core of high CA systems. Composite model which is created by this procedure comprises necessary information about its own conditions (thickness of single composite layers, orientation and position of composite plies, boundary of composite layers, mass properties, material and structural characteristic). This form of data packet is parallel sent in the logical and comparing section of the special core of the CAE system where powerful testing and comparing tools are applied for harvesting the suitable structural composition of the single composite layers. By means of these mentioned steps the composite model is filled with important information and then the data packet is ready to be exported to system of AR. In the second phase of the composite construction creation the single composite ply is applied and provided with the exact orientation and position for this layer needs for fixation in the particular place of the auxiliary model in the real environment. Nowadays application allow the designer to use different methods where the characteristic feature lies in a technology of visualization of the composite boundary ply. This group of the technology of visualization process includes general methods such as composite template, laser visualization method of the displaying composite boundary and composite augmented reality process [2].

The PlyMatch (Ply Placement Technology) from Anaglyph Ltd Corporation UK presents special software tools for the engineering community and provide powerful software and hardware equipments for creation of construction ideas which consist of many composite layers. This company is a leader in the science area dealing with the advanced composite software tools for execution of composite design and analysis. Final composite solution includes the exact ply geometry with no mistakes. The PlyMatch was produced to define the exact position and orientation for hand lay-up manufacturing process of composite layers. Anaglyph Ltd Corporation provides important solution for the special customers whose general manufacture activity is concerned with areas like aviation and aerospace industry. The PlyMatch System is available in flexible configurations to suit the requirements of every end-user. It includes PC with suitable display, placement software for plies allocation definition, Laminate Tools software extensions for video and probation of interfaces and image blending, digital camera with boom stand and as most important part also coordinate measuring machine that provides exact information about all necessary geometries from real working environment as is presented on Fig. 1 [3].

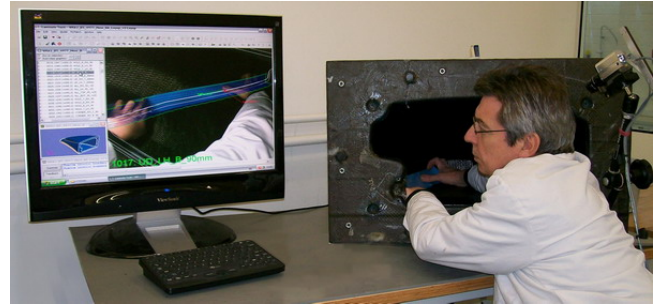


Fig. 1 Example of the PlyMath visualization system application [3]

Another possible application in industrial praxis is visualization by 3D laser projection. It is accomplished by steering a single laser beam accurately through a series of specific points in space. The laser beam is directed at a pair of mirrors that are powered by a set of galvanometers called computer controlled servo motors which are capable of extremely rapid movement. The effect that is produced is a highly visible, glowing three dimensional template that is used as a location guide during a manufacturing process. This technology is richly exploited by Laser Projection Technologies Inc. Their systems replace conventional assembly methods and hard manufacturing templates in a wide variety of applications. 3D laser projectors use 3D component or part placement, paint masking and templates creating, vehicle and structural assembly, composite ply lay-up and core placement [4].

## 2.1 Special composite models for supporting of analytical processes

Software for the production of composite parts must meet several conditions, including the ability to close the establishment of iterations not only between the designer and integrated CAD software, but also between the analytical software that serves to optimize the design and verification of the structural integrity. By establishing such a connection the loop is closed in analysis of the composition and the actual designer. Based on a composite analysis using finite element method (FEM), the required parameters are defined by identifying changes in the proposal such as material thickness and type of composite.

The drafting of a new form from composite materials requires the designers to take care of certain characteristics such as weight reducing and strength increasing. To consider these terms means that the concept becomes very difficult and expensive. These drawbacks can be eliminated simply by selecting the appropriate composition of the development environment in which the module is implemented only for the generation of the

conceptual design, but at the same time also with excellent analytical features (Fig. 2).

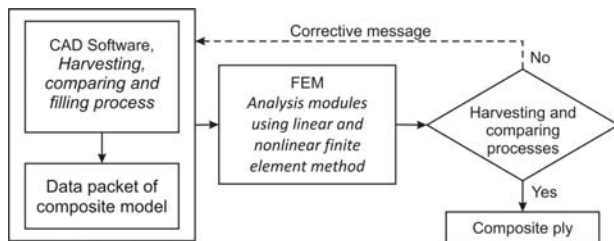


Fig. 2 Algorithm of particular composite ply testing by finite elements method (FEM)

On the base of these data information can be specified the size, thickness and orientations of individual fibers in the various stages of the proposal. These factors are applied to the process of examining and determining the mechanical properties of multilayer composites such as thermal expansion, strength, permeability and stiffness.

### 3 Software Solution for AR Visualization in Composite Assembly Process

On the beginning of programming process it is necessary to start with the creation of basic simply logical scripts which were connected into more difficult logical loops by virtual tools of the application that offers unlimited possibilities of the composite augmented designing process. Solution called Virtools present software system for the creating of virtual application that was developed at 2005 by Dassault Systemes. This application allows executing an extended connection between behaviour conditions and elements in the same virtual composition. All these operations are realized by special logical component called Behaviour Building Blocks (BBs). BBs provide the tool that uses simple graphical interface to create logical joints for information package. All BBs from the virtual library comprises an input/output pin that can be linked and configured by requests and orders from the user. Application environment and special tools provide possibilities to collect and observe information about the data flow between single BBs. The logical core of this virtual environment gives the solution where the single BBs are connected between them and the space which comprises this logical BBs loops, called Behaviour Graph (BG). The Virtools provides this possibility for costumers and opens up virtual space for unlimited ideas of augmented designing. This method, where the program or composition is realized by logical connection between BBs is called visual scripting.

In the following example the logical scheme explains some basic logical loops in the BG and structures which were applied in the particular parts of the mentioned application. Some logical parts of the behaviour graph were implemented from the existing loops and consecutively were adjusted into the new form [5].

#### 3.1 Behaviour graph for starting button

The BG and processing algorithm showed on the Fig. 3 deals a view on the logical loop which includes necessary BBs for observing the starting button (flystick or keyboard button). The mentioned BG is activated by confirming the starting button after that sends the message about this action on the exact places into the particularly space of the application of the AR (where the following processes are started by means of the confirming message which activates the exact logical loops and manages orders in the BBs).

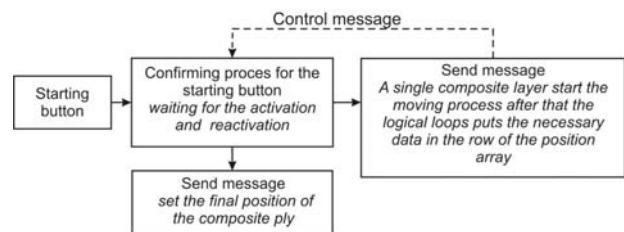


Fig. 3 Logical loop with BBs for observing the starting button

Next, by reactivating the button again, the logical BBs called Wait Button (which offers tools for observing the starting button during the entire cycle) which sends the message about this action again into the particularly space of this application (for the activating process of the exact logical loops and manages orders in the BBs).

#### 3.2 Behaviour graph for data filling

The simple example situated below shows the special BG and logical algorithm for the process of data filling (Fig. 4). The logical script, where the arrays are filled by information about models and their initial conditions is activated by confirming message which is sent from the BG for the starting button. The first step in this process is an operation where the identification names of all composite layers from working environment are written into the exact position of the data array. This array is filled by means of adjustments of the behaviour conditions of the BBs called Iterator. By using the logical BBs called Get Position and Set Row the identification name of a composite ply from

working environment assigns initial condition and behaviour about its position in the data array.

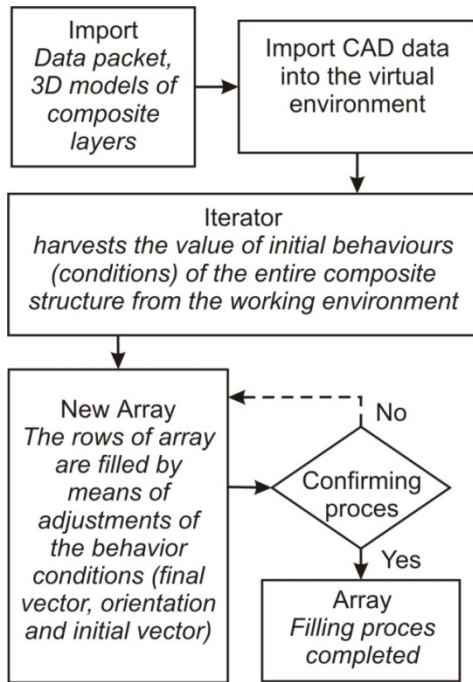


Fig. 4 Algorithm for the process of data filling

On the base of these orders and requests the new array comprises the important parameters such as final vector, orientation and initial vector of the entire composite layers structure. These mentioned parameters are necessary to harvest the value of initial behaviours (characteristics) of all composite parts from working environment. On the ground of the initial values from the Array and by their activation the special logical loops of another BG are initiated and process starts where particular 3D models of composite ply are able to move on their own trajectory.

### 3.3 Behaviour graph for motion tracking

The algorithm displayed on the Fig. 5 provides schematic information about the process where data from the marker and motion tracking system are harvested and evaluated by computer and then implemented into the 3D environment of the mentioned virtual composite application. The first part of the algorithm comprises three basic areas such as area for testing and comparing, area for setting position (initial, final position) and area for moving trajectory. At the beginning, after confirming starting button, the application reads data from array which was created before the main initiation by the user. This data include information about the names of all composite models and their values of initial vectors and final parameters of position. Then the harvested data from behaviour

graph called ART capture are sent into the area for testing and comparing with each other and with array data (initial, final position). Then the 3D models from the first row array are applied into the marker position (information from the special BBs ART capture) and they are rewritten for the fixed position from array. After the area of movement trajectory is activated by a logical loop, the animation is displayed where the 3D model provides trajectory for the applying of an assembling (virtual template or virtual advice for user's work).

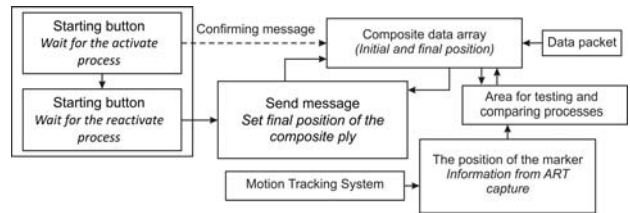


Fig. 5 Process of marker and motion tracking system data evaluation

### 3.4 Logical core of composite assembly visual application

Next BG showed in the Fig. 6 provides a view on general logical loops for adjusting and comparing information from ATR capture outputs. By means of these, the Iterator assigns correct information about the name of the all 3D composite parts (which should be applied into the virtual environment by operation order from the logical loops) from the relevant row into the data array. Thanks to them the controlling instructions are available like necessary parameters about the final vector, orientation and initial vector from previous steps of the logical loop of this application.

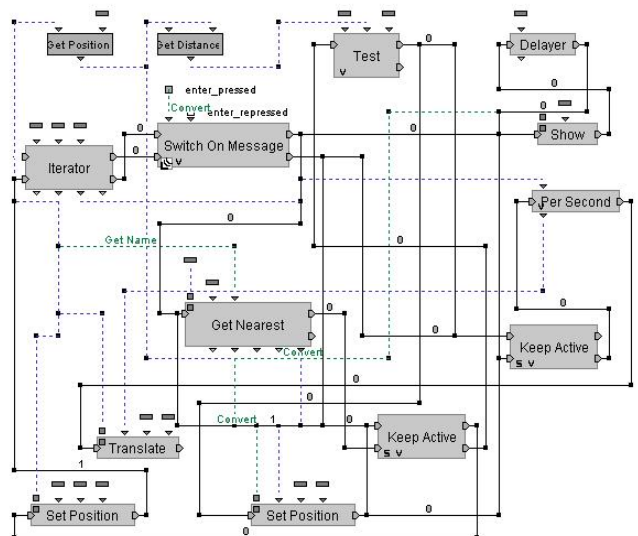


Fig. 6 Schematic information about processes of manage data into the core of application



All these logical elements are concentrated into the special logical space called Loading section. Concurrently with this mentioned process all these position parameters are sent and assigned into the BBs called Get Position where it waits for the activating order to movement into the comparative section of the behaviour graph. In the section for comparing, the received data are considered by various BBs to handle and evaluate real data among the virtual ones. These logical elements replace and identify coordinate system of the marker in the real environment with the auxiliary elements of virtual space. Connection realized by applying previous elements opens up basic possibilities of augmented reality where real view is associated and overlapped with the 3D environment. The new coordinate system obtains the important information from the comparing section on account of which the logical loop displays the process of moving of the particular 3D composite layer on its trajectory whose positional parameters are sent from data array. To simplify, by means of the positional data from the marker of tracking system the application is able to assign the virtual coordinate system in the centre of marker (Fig. 7). After that, the data cell for comparing positional conditions recalculates and evaluates necessary value of the 3D composite part to follow identification with the real system. The BBs called Switch on Message constantly controls and observes the parameter that gives information about button reactivation.

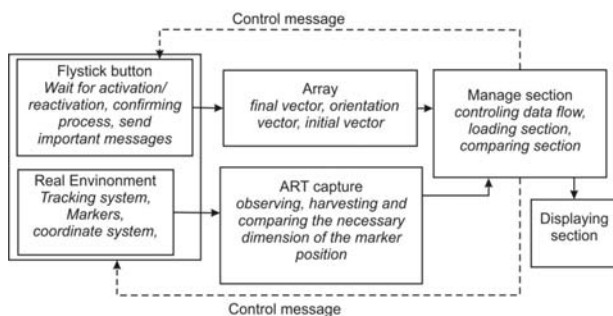


Fig. 7 Managing of external data and their use in the core of the application

Thanks to them, visualization section situated among the comparing space and the positional one stands in front of the possibilities to show both variants (displaying the movement trajectories for all 3D composite plies or values of the final vector position after that designer can see the boundary edge of composite layer). If the button is pressed once, the BBs Switch on Message receives the confirming message and then the necessary information of the composite ply is sent from the data array by Iterator (Loading section) to positional

and comparing space. Then, the relevant order consequently continues to the displaying section where the final process is assembled and the customer is able to see the process of the moving of the composite ply on its trajectory. This mentioned process of moving is repeated until the time when the button is reactivated and the BBs Switch on Message receives the confirming message again, after that the moving process is stopped and substituted by the value which is characterized as a vector of the final position from the data array. By mean of these steps the designer can see the boundary edge of the virtual composite layer in the real view. If the button is pressed again, the BBs Iterator sends order to the change where the position of the row in the data array is moved to lower line. On the basis of these processes, all new information of position and orientation are sent again into the logical spaces of behaviour graph where the new coming parameters are tested, compared and evaluated between each other. After that, the displaying section is able to see the process of the moving of the following composite layer on its trajectory (Fig. 8).

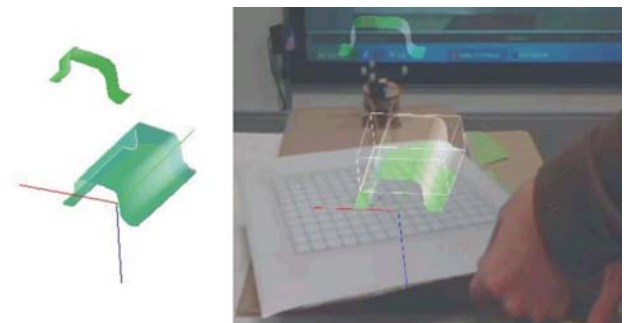


Fig. 8 Visualization of the augmented reality aided composite assembly manufacturing process

### 3.5 Plug-in of Augmented Reality for visualization of composite assembly

On the next example the logical core of the augmented reality which was mentioned in the previous sentences allows user to understand augmented steps of the operation and imagine about composite problem. The designer needs to find exact position and orientation for all ply of composite model (the exact boundary edge of composite layer) and to obtain necessary information about the simply composite layer. The exact and complex process of creating the composite ply by special designer tools of CAD software is essential value of this application. During of this process and realizing of important steps of this implementation hierarchy the logical algorithm defines important parameters which are

necessary to create the effective construction elements of composite model. By mean of these items the information can be separated in the two different groups which provide initial conditions about the composite ply from two sides. One side deals with the user information like mass properties, material of composite ply, Delivery Company, costumer ID). All these parameters are absolutely defined by special tools for the filling of parameters on the basis of which the data packets which are mentioned in the previous pages are created. Other side deals with the groups of data which comprise information that have construction characteristic or geometric condition like information necessary to determine the exact position of composite ply, thickness of ply, orientation in the 3D environment, moves, rotations and coordinate system information (Fig. 9). This last group allows costumer to see the exact boundaries of all composite plies and also for this reason user knows the initial position of this ply [6].

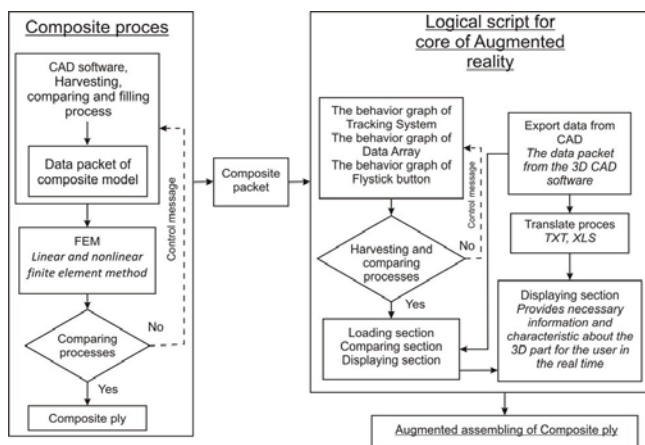


Fig. 9 Algorithm of augmented reality composite assembly process application

## 4 Conclusion

This paper deals with area of implementation possibilities of augmented reality for the visualization of the composite structures creation. There are more aspects included in the problems of entire composite assembling process. It concerns software issues reflecting the model geometry (single composite ply) as well as displaying of final boundaries for all composite layers of whole structure. Created application was focused on the later mentioned part of the problem where designer needs to know exact positions of particular composite layers in the real environment eventually with respect to auxiliary object.

Implementation of augmented reality elements in manufacturing process visualization shows that these problems are free to be developed and their

solutions realized in many industrial spheres. Effective creation of composite structures and other produced parts is one of application areas where the productivity and efficiency of work as well as quality of achieved results can be highly increased by utilization of suitable combination of progressive software and hardware tools [7].

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### References:

- [1] S. K. Ong, A. Y. C. Nee, *Virtual and Augmented Reality Applications in Manufacturing*, Springer-Verlag, London, 2004
- [2] S. H. Choi, H. H. Cheung, A versatile virtual prototyping system for rapid product development, *Computers in Industry*, Vol. 59, 2008, pp. 477–488.
- [3] M. Pouliquen A. Bernard, J. Marsot, L. Chodorge, Virtual hands and virtual reality multimodal platform to design safer industrial systems, *Computers in Industry*, Vol. 58, 2007, pp. 46–56.
- [4] M. Bordegoni, G. Colombo, L. Formentini, Haptic technologies for the conceptual and validation phases of product design. *Computer & Graphics*, Vol. 30, 2006, pp. 377-390.
- [5] V. Fecova, J. Barna, J. N. Marcincin, M. Janak, L. N. Marcincinova, J. Torok, Visualization of Composite Lay-Up Technology with use of Augmented Reality Elements. *Proceedings of on Applied Machine Intelligence and Informatics SAMI*, Obuda University Budapest, 2012, pp. 173-177, ISBN 978-1-4577-0195-5.
- [6] J. N. Marcincin, J. Barna, M. Janak, V. Fecova, L. N. Marcincinova, Composite lay-up process with application of elements of augmented reality, *Engineering Reality of Virtual Reality*, Vol. 8289, 2012, p. 1-6, ISSN 0277-786X.
- [7] J. N. Marcincin, P. Brazda, M. Janak, M. Kocisko, Application of Virtual Reality Technology in Simulation of Automated Workplaces. *Technical Gazette*, Vol. 18, No. 4, 2011, pp. 577-580, ISSN 1330-3651.