Editorial Board

International Scientific Committee
Anna BŁACH, Ted BRANOFF (USA), Modris DOBELIS (Latvia), Bogusław JANUSZEWSKI, Natalia KAYGORODTSEVA (Russia), Cornelia LEOPOLD (Germany), Vsevolod Y. MIKHAILENKO (Ukraine), Jarosław MIRSKI, Vidmantas NENORTA (Lithuania), Pavel PECH (Czech Republic), Stefan PRZEWŁOCKI, Leonid SHABEKA (Belarus), Daniela VELICHOVÁ (Slovakia), Krzysztof WITCZYŃSKI

Editor-in-Chief
Edwin KOŹNIEWSKI

Associate Editors
Renata GÓRSKA, Maciej PIEKARSKI, Krzysztof T. TYTKOWSKI

Secretary
Monika SROKA-BIZOŃ

Executive Editors
Danuta BOMBIK (vol. 1-18), Krzysztof T. TYTKOWSKI (vol. 19-31)

English Language Editor
Barbara SKARKA

Marian PALEJ – PTGiGI founder, initiator and the Editor-in-Chief of BIULETYN between 1996-2001

All the papers in this journal have been reviewed

Editorial office address:
44-100 Gliwice, ul. Krzywoustego 7, POLAND
phone: (+48 32) 237 26 58

Bank account of PTGiGI: Lukas Bank 94 1940 1076 3058 1799 0000 0000

ISSN 1644 - 9363

Publication date: December 2018 Circulation: 100 issues.
Retail price: 15 PLN (4 EU)
CONTENTS

PART I: THEORY (TEORIA)
1 A. Borowska: APPROXIMATION OF THE SPHEROID OFFSET SURFACE AND THE TORUS OFFSET SURFACE 3

PART II: GRAPHICS EDUCATION (DYDAKTYKA)
1 K. Banaszak: CONIC SECTIONS IN AXONOMETRIC PROJECTION 11
2 B. Kotarska-Lewandowska: BETWEEN DESCRIPTIVE GEOMETRY AND CAD 3D 15
3 C. Łapińska, A. Ogorzałek: CHARACTERISTIC POINTS OF CONICS IN THE NET-LIKE METHOD OF CONSTRUCTION 21
4 O. Nikitenko, I. Kurnytyshka, A. Kalinin, V. Duman-saleja: DESCRIPTIVE GEOMETRY COURSE ADDRESSED TO THE CIVIL ENGINEERING STUDENTS AT ODESSA STATE ACADEMY 29
5 F. N. Pirtykin, N. V. Kaygorodtseva, M. N. Odiets, I. V. Krysova: ROBOTICS AS MOTIVATION OF LEARNING TO GEOMETRY AND GRAPHICS 35

PART III: APPLICATIONS (ZASTOSOWANIA)
1 A. Borowska: APPROXIMATION OF THE ELLIPSE OFFSET CURVES IN TURBO ROUNDABOUTS DESIGN 43
2 A. Borowska: APPROXIMATION OF THE OFFSET CURVES IN THE FORMATION OF TURBO ROUNDABOUTS 53
3 O. Nikitenko, I. Kurnytyshka: GEOMETRIC MODELLING OF CONJUGATE RULED SURFACES WITH USING THE KINEMATIC SCREW DIAGRAM 61
4 K. Panchuk, E. Lyubchinov: SPATIAL CYCLOGRAPHIC MODELING ON NAUMOVICH HYPERDRAWING 69

PART IV: HISTORY OF DESCRIPTIVE GEOMETRY (HISTORIA GEOMETRII WYKREŚLNEJ)
1 E. Koźniewski: WYBRANE KONSTRUKCJE GEOMETRYCZNE W SŁOWNIKU WYRAZÓW TECHNICZNYCH TYCZĄCYCH SIĘ BUDOWNICTWA TEOFILA ŽEBRAWSKIEGO 79

PART V: INFORMATION AND NEWS (WYDARZENIA I INFORMACJE)
1 REVIEWERS 2018 14
BETWEEN DESCRIPTIVE GEOMETRY AND CAD 3D

Bożena KOTARSKA-LEWANDOWSKA

Gdansk University of Technology, Department of Structural Mechanics of Materials and Structures
ul. G. Narutowicza 11/12, 80-233 Gdańsk, POLAND
email: bokot@pg.gda.pl

Abstract. Descriptive geometry (DG) provides methods to analyse three-dimensional space through two-dimensional drawings and prepares to create technical documentation. Geometric form of an engineering project is presented by the means of projection methods based on a 3D model, which is present in designer’s imagination. The forthcoming era of Building Information Modelling (BIM) brings changes in the way the engineer works, as the vision is translated directly from the designer’s mind into a digital model. The main tasks concern creation of the model and the two-dimensional documentation is obtained automatically. Currently during the first semester of study, every engineering student participates in a descriptive geometry module, adjusted to the specific requirements of the given course. 3D modelling programs are introduced throughout the course of study. In both cases the academic aim is to develop competency in effective operation in space. Therefore, it is worth investigating which skills acquired through the descriptive geometry education can be applied in the initial stage of 3D modelling. The paper attempts to develop an introduction to 3D modelling which takes into consideration skills acquired from the previous experience in descriptive geometry with a reference to the issues of modelling. The aim is not to present topics from descriptive geometry in the digital environment but to apply its knowledge in modelling and creating of 2D documentation in practice. When constructing the content of such an introduction, it is necessary to select previously learned constructions and algorithms, but also do not limit the creative approach. At the same time it is difficult to ignore the fact that many of the key issues for descriptive geometry in a digital environment can be achieved with one click. The formulation of the problem should therefore include options for available solutions in selected software. The paper presents some tasks for building solids, creating tangent surface, setting defined views and many more.

Keywords: descriptive geometry, 3D modelling, graphics education, BIM

1 Impact of BIM on engineering education
BIM is a very broad term that describes the process of creating and managing digital information about buildings in their lifecycle. This comprehensive approach is expressed in a definition formulated by buildingSMART alliance which sequentially refers to all aspects of design, construction and operation of the building ([2, 3, 5]) (Table 1).

Table 1: BIM definition. 3D Model is a medium for collecting and transferring data [3]

<table>
<thead>
<tr>
<th>Components</th>
<th>Progressive BIM definition</th>
<th>The role of a 3D model - examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information about the model</td>
<td>Record of a digital 3D model</td>
<td>Record of geometric form, visual assessment of a project at early stage, database, detection of collisions, visualisation at different stages, mean of collaboration within the project team, mean of information exchange</td>
</tr>
<tr>
<td>Information about modelling</td>
<td>The creative process of modeling from design to function, detailing on each stage</td>
<td></td>
</tr>
<tr>
<td>Information about management</td>
<td>Organization and control of investment processes</td>
<td></td>
</tr>
</tbody>
</table>

BIM process is complex and involves all parties from architect, structural and MEP engineers, contractors to owners etc. It consists of a technological base and also the layers of social components such as synchronous collaboration, coordinated work practices and
institutional and cultural framework. In the initial stages a 3D model appears, and then various data is added to its different parts; a 3D model is the axis of the whole process, it is used for cooperation and communication.

These processes require teams to work in a variety of digital environments, the project delivery team collaborate through Common Data Environment (CDE). Technological advances in production and information flow are reflected in BIM maturity stages (Table 2). Currently Level 2 BIM in the industry and education is standard in many countries.

Table 2: Maturity levels of BIM, reflecting technological advancement [5]

<table>
<thead>
<tr>
<th>Level</th>
<th>Feature</th>
<th>Content</th>
<th>Application in practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Object-based modelling</td>
<td>- 2D drawings and/or a 3D object-oriented model with basic data attached</td>
<td>- transition from hand drawing and CAD to BIM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- seamless visualisation</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- asynchronous communication</td>
<td></td>
</tr>
<tr>
<td>Level 2</td>
<td>Model-based collaboration</td>
<td>- a managed 3D environment created from separate discipline models</td>
<td>- currently Level 2 BIM in the industry and education is standard in many countries</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- information share and exchange, 4D 5D</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- clash detection between disciplines</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- asynchronous communication</td>
<td></td>
</tr>
<tr>
<td>Level 3</td>
<td>Network-based integration</td>
<td>- a single, integrated, online n-model</td>
<td>- the new technology providing Unified Modelling Language tools is going to be implemented from 2021 to 2025</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- complex analysis at early stages: sustainability, constructability, costing, lifecycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- streamlined lean process</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- synchronise communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- multi-server process for communication</td>
<td></td>
</tr>
</tbody>
</table>

Due to its advantages, BIM becomes essential in modern design processes. Universities worldwide include BIM in their curriculum in order to transform students into a BIM-ready graduates who can be competitive on the labour market as they better integrate visualizations and data into their projects. Including BIM content into engineering education can cause restructuring the existing curriculum as BIM is not just an ordinary subject which is to be added to the current curricula. It is a very complex methodology deeply rooted in the advanced technology concepts which requires changes in teaching, especially in terms of collaborative work, integration and coordination methods [1,4]. For these reasons, considering how in the early semester these processes can be supported, the borders among geometry, technology and collaborative work were investigated from the didactic perspective (Fig. 1).

**Figure 1:** The analysis of three overlapping essential areas of BIM: geometry, technology and collaborative work
In the overlapping areas new fields arise for instant implementation in current education: geometry in CAD, CAD in geometry and group projects for descriptive geometry. It seems that integrating mentioned areas may result in smoother preparation for BIM at later semesters.

2 The descriptive geometry content in CAD education

Academic subjects of descriptive geometry and CAD should support skills of constructing proper 3D models. In both cases the academic aim is to develop competency in effective operation is space. Although the aim is to be obtained with different means, it refers to the same intellectual operations related to the perception of space (Table 3).

<table>
<thead>
<tr>
<th>Task Aspect</th>
<th>Descriptive Geometry</th>
<th>CAD 3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task objectives</td>
<td>- creating projection views</td>
<td>- 3D form modelling</td>
</tr>
<tr>
<td></td>
<td>- intersection line, cross-section</td>
<td>- getting 2D view documentation</td>
</tr>
<tr>
<td></td>
<td>- building solids/surfaces</td>
<td>- visualization</td>
</tr>
<tr>
<td>Workspace</td>
<td>- 2D plane of the drawing</td>
<td>- 3D virtual space</td>
</tr>
<tr>
<td></td>
<td>- lines, circles, curves</td>
<td>- draw, modify applications</td>
</tr>
<tr>
<td>Building spatial forms/</td>
<td>- multi-step action</td>
<td>- often single-click mouse operation</td>
</tr>
<tr>
<td></td>
<td>- additional construction planes</td>
<td>- work plane (UCS)</td>
</tr>
<tr>
<td></td>
<td>- transformation</td>
<td>- modelling command</td>
</tr>
<tr>
<td></td>
<td>- rotation</td>
<td>- solid edit commands</td>
</tr>
<tr>
<td></td>
<td>- scaling</td>
<td>- a model without scaling</td>
</tr>
<tr>
<td>Intersection, cross-section</td>
<td>- multi-step operation</td>
<td>- single-click mouse operation</td>
</tr>
<tr>
<td></td>
<td>- additional construction planes</td>
<td>- Boolean Operation; unite, subtract, intersect</td>
</tr>
<tr>
<td></td>
<td>- transformation on the drawing plane</td>
<td>- intersection</td>
</tr>
<tr>
<td></td>
<td>- rotation of the plane</td>
<td>- slice command</td>
</tr>
<tr>
<td>Views/Visualization</td>
<td>- constructing orthogonal, axonometric or perspective views</td>
<td>- automatic switching to perspective, orthogonal, axonometric views – Layout, model base</td>
</tr>
</tbody>
</table>

Comparison of task aspects in descriptive geometry and CAD show that:
- the main operations in DG are transformation and rotation, whereas in CAD they are rotation and dynamic UCS,
- the main DG objectives as intersection line and cross-section are available in CAD as a single click operation,
- the main action in DG is creation 2D from 3D imaginary object, whereas in CAD it is the reverse action – building 3D often given 2D views,
- spatial visualization is needed in both DG and CAD.

Many developed constructions in descriptive geometry course are just a single-click mouse operation (e.g. in AutoCAD belonging to a plane, natural size of polygons, distance between points, intersection line, cross-section can be obtained immediately). Therefore the task should be formulated so that multi-step operation would be needed to find the solution of geometric issues. It seems that such issues might be building 3D model from 2D views, creating solids based on spatial relations such as tangency, rotation, alignment, etc.

3 Examples of tasks in AutoCAD

The group of tasks where creating 3D models based on 2D drawing of orthogonal or axonometric projection views was proposed (Fig. 2, Fig. 3). The bases and the polyhedral should be properly rebuild, while the intersection line is automatically obtained.
Another group may be tasks involving tangency: determine a plane tangent to a given solid (Fig. 4), or move one solid, that it would be tangent to the other one (Fig. 5).

Figure 2: Reconstruction of a polyhedron and an intersecting plane. The intersection is obtained by the slice command (AutoCAD 2017)

Figure 3: Reconstruction of two polyhedrons given their projection views; intersection appears as an automatic result (AutoCAD 2017)

Figure 4: Creating planes tangent to given solids passing through a point or a line (AutoCAD 2017)
In another task it was necessary to set the positions of the octahedron in the model space, that the views obtained through automatic creation of documentation in the paper space would be the same as required (Fig. 6). The octahedron should be repeatedly rotated in various ways.

![Image of octahedron models](image)

**Figure 5:** Moving the cylinder to the position tangent to the second cylinder (AutoCAD 2017)

**Figure 6:** Obtaining predefined views of the octahedron by using Base Views command (AutoCAD 2017)

### 4 Conclusions

BIM changes engineer’s work and soon it will become a standard in education; for Civil Engineering Faculty teaching CAD as two-dimensional drawings is already insufficient. As BIM increases the importance of modelling, the education of descriptive geometry and CAD needs to be adjusted. At the current stage, it seems that the value enhancing modelling is to find a connection between DG and technology - the geometry course can be supplemented with CAD, and CAD course should include elements of descriptive geometry. From the presented analysis, it is apparent that the essential skills for CAD course which are taught in DG are: creating 2D views from 3D model and vice versa, rotation-UCS, spatial relations. The introduction to 3D modelling can relate to those skills which should not be available automatically. The BIM workflow requires cooperation; therefore, the geometry curriculum should introduce group projects which would also relate to practical issues.
POMIĘDZYZ GEOMETRIĄ WYKRĘŚLNĄ A CAD 3D

Przedmiot geometria wykreślna dostarcza metod do działania w przestrzeni trójwymiarowej poprzez dwuwymiarowe rysunki i przygotowuje do tworzenia rysunków technicznych. Nadchodząca era technologii BIM przynosi zmiany procesu zapisu formy przestrzennej projektu. Wizja projektowanego obiektu wprost z umysłu projektanta przenosi się na model 3D powstający w środowisku cyfrowym. Główne działania projektanta dotyczą więc bezpośrednio tworzenia modelu; dokumentacja 2D jest uzyskiwana w sposób automatyczny.

Obecnie studenci kierunków inżynierskich poznać geometrię wykreślną dostosowaną do specjalności, jednocześnie w toku studiów poznać także programy do modelowania obiektów 3D. W obu przypadkach celem edukacyjnym jest wykształcenie kompetencji do skutecznego działania w przestrzeni. Chociaż cel ten jest uzyskiwany za pomocą różnych środków, to jednak dotyczy tych samych operacji umysłowych. W artykule podjęto próbę przedstawienia takiego wprowadzenia do modelowania, które uwzględniałoby zdobyte wcześniej doświadczenie z geometrią wykreślną. W tym podejściu działania wykonywane są bezpośrednio na modelu, operacje takie jak obroty czy transformacje można obserwować tylko w momencie ich tworzenia, a później ślad po nich znika. Konstruując treści takiego wprowadzenia należy więc dobierać zadania które generują geometryczne myślenie oraz przywołują poznane wcześniej konstrukcje i algorytmy. Nie sposób także zignorować faktu, że wiele problemów kluczowych dla geometrii wykreślnej, w środowisku cyfrowym można rozwiązać jednym kliknięciem, bez żadnych konstrukcji; przykładowo dotyczy to zagadnienia przechodzeni czy przenikania. Trzeba zatem formułować takie zadania, których nie można uzyskać automatycznie, i których rozwiązanie wymaga utworzenia pewnej strategii konstrukcyjnej.

References