Erasmus+ Programme Key Action 2 Cooperation Partnerships
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Agreement number 2023-1-RO01-KA220-HED-000155412
European Network for Additive Manufacturing in Industrial Design for Ukrainian Context Contextternational S.A., Madrid, Spain, 7-10 May 2024

Staff Training – Edibon International S.A., Madrid, Spain, 7-10 May 2024

REVERSE ENGINEERING

Remigiusz LABUDZKI,
remigiusz.labudzki@put.poznan.pl
Poznan University of Technology

Natalia WIERZBICKA,
natalia.wierzbicka@put.poznan.pl
Poznan University of Technology

Staff Training – Edibon International S.A., Madrid, Spain, 7-10 May 2024

AGENDA

1. Poznan University of Technology (PUT) – role in education
2. PUT AMAZE Team
3. Reverse Engineering – basics
4. Reverse Engineering - applications

Poznan
University
Of Technology

POZNAN UNIVERSITY OF TECHNOLOGY

WELCOME TO
POZNAN UNIVERSITY OF TECHNOLOGY

POZNAN UNIVERSITY OF TECHNOLOGY

Poznan University of Technology (PUT) was established in **1919** as a **State Higher School of Mechanical Engineering**.

Since 1955 it has been named **Poznan University of Technology**.

One of the leading technical universities in Poland which has become one of the most recognized landmarks of the region.

100TH ANNIVERSARY OF TECHNICAL HIGHER EDUCATION IN POZNAN

Great combination of

tradition & INNOVATION

POZNAN UNIVERSITY OF TECHNOLOGY

Eunice

EUROPEAN UNIVERSITY

POZNAN UNIVERSITY OF TECHNOLOGY

EUROPEAN UNIVERSITY

European University for Customised Education

- **PUT** – Poznan University of Technology – leader of EUNICE Alliance
- **BTU** – Brandenburg University of Technology Cottbus-Senftenberg
- **UMONS** – University of Mons
- **UC** – University of Cantabria
- **UNICT** – University of Catania
- **UPHF** – Université Polytechnique Hauts-de-France
- **UVA** – University of Vaasa
- **UoP** – University of the Peloponnese
- **IPV** – Polytechnic Institute of Viseu
- **KU** – Karlstad University

POZNAN UNIVERSITY OF TECHNOLOGY

PUT IN NUMBERS

- **9** faculties
- **more than 14** thousand students

(more than 1000 of them are international)

- **more than 40** fields of study
- **8** BSc programs in English
- **22** MSc options in English
- **324** labs
- **2368** employees
- **1342** academic staff
- **more than 2000** places in dormitories

POZNAN UNIVERSITY OF TECHNOLOGY

PUT IN RANKINGS

Poznan University of Technology maintained its position (1201-1500) in **WUR 2024**, achieving 15th place among Polish universities.

WUR 2024 by subject:

- Business and Economics (601–800)
- Computer Science (801–1000)
- Engineering (801–1000)
- Physical Sciences (801–1000)

QS WORLD UNIVERSITY RANKINGS 2024.TOP GLOBAL UNIVERSITIES: PUT was among 22 Polish universities classified in the list of the best universities in the world and was ranked 5th among Polish technical universities

47 Researchers from PUT are on the list of the world's most cited researchers - top 2% list prepared by Stanford University (in cooperation Elsevier)

POZNAN UNIVERSITY OF TECHNOLOGY

PUT FACULTIES

FACULTY OF **ARCHITECTURE**

FACULTY OF **CIVIL AND TRANSPORT ENGINEERING**

FACULTY OF **CONTROL, ROBOTICS AND ELECTRICAL ENGINEERING**

FACULTY OF **COMPUTING AND TELECOMMUNICATIONS**

FACULTY OF **MATERIALS ENGINEERING AND TECHNICAL PHYSICS**

FACULTY OF **ENVIRONMENTAL ENGINEERING AND ENERGY**

FACULTY OF **ENGINEERING MANAGEMENT**

FACULTY OF **MECHANICAL ENGINEERING**

FACULTY OF **CHEMICAL TECHNOLOGY**

POZNAN UNIVERSITY OF TECHNOLOGY

CAMPUS

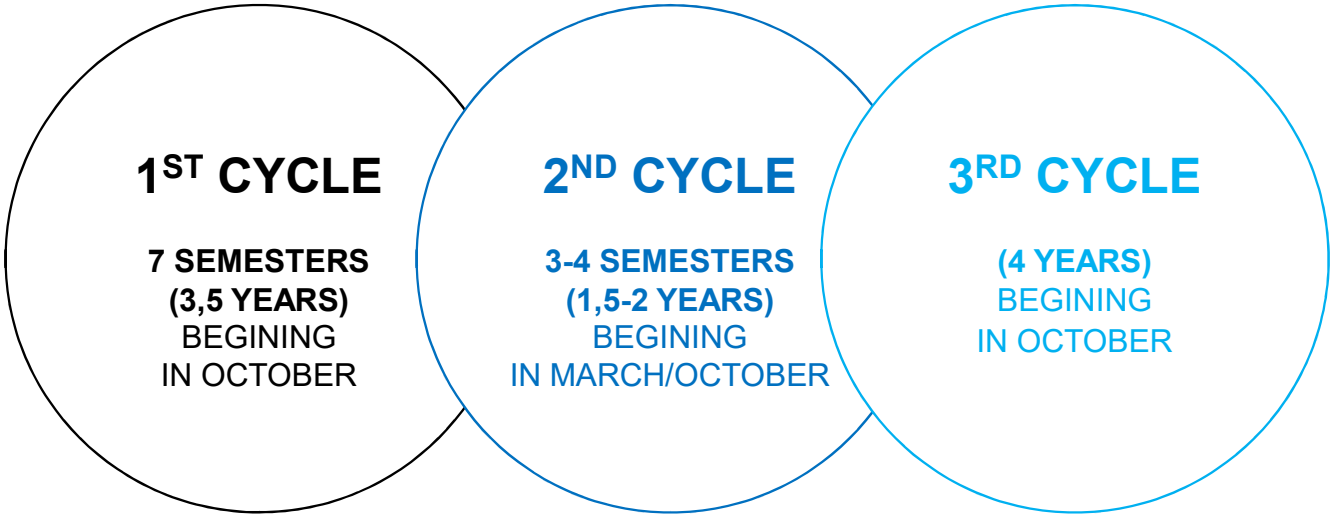
- on the banks of the Warta River
- 10 minutes from the Old Market Square
- 5 minutes to Malta Lake

POZNAN UNIVERSITY OF TECHNOLOGY

OPENING OF KAKOLEWO CAMPUS (Sept. 2022)

POZNAN UNIVERSITY OF TECHNOLOGY

HIGHER EDUCATION SYSTEM at PUT



POZNAN UNIVERSITY OF TECHNOLOGY

PROGRAMS IN ENGLISH

Currently PUT offers **8 B.Sc. Programs** in English

+ NEW B.Sc. Program in **Biomedical Engineering**

POZNAN UNIVERSITY OF TECHNOLOGY

PROGRAMS IN ENGLISH

and **22 options at M.Sc. level** in English (1):

- Civil Engineering - Construction Engineering and Management
- Civil Engineering - Structural Engineering
- Computing - Cybersecurity
- Computing - Software Engineering
- Architecture
- Product Lifecycle Engineering
- Chemical Technology - Composites and Nanomaterials
- Electronics and Telecommunications - Information and Communication Technologies
- Engineering Management - Managing Enterprise of the Future *(+Double degree option with Université Lille 1, France)*
- Mechanical and Automotive Engineering - Product Engineering

POZNAN UNIVERSITY OF TECHNOLOGY

PROGRAMS IN ENGLISH

and **22 options at M.Sc. level** in English (1):

- Logistics - Logistics Systems
- Automatic Control and Robotics - Smart Aerospace and Autonomous Systems
- Transport - Sustainable Transport
- Green Energy[new]
- Artificial Intelligence
- Electrical Engineering - Drive Systems in Industry and Electromobility[new]
- Electrical Engineering - Electrical Systems in Industry and Vehicles[new]
- Electrical Engineering - Lighting Engineering[new]
- Electrical Engineering - Microprocessor Control Systems in Electrical Engineering[new]
- Electrical Engineering - Smart Measurement Systems[new]
- Biomedical Engineering[new]
- Mechatronics[new]

POZNAN UNIVERSITY OF TECHNOLOGY

COOPERATION WITH INDUSTRY

POZNAN UNIVERSITY OF TECHNOLOGY

PUT INTERNATIONAL STUDENTS COME FROM OVER **60 COUNTRIES**

POZNAN UNIVERSITY OF TECHNOLOGY

INTERCULTURAL EVENTS

Poznan University of Technology TEAM

PhD Remigiusz ŁABUDZKI
Assistant Professor/
PUT AMAZE Coordinator

PhD Student Natalia WIERZBCKA
Assistant

PhD Adam PATALAS
Assistant

PhD Student Paweł ZAWADZKI
Assistant

PhD Student Jakub Gapsa

PhD Remigiusz ŁABUDZKI

Assistant Professor/PUT AMAZE Coordinator

Position – senior lecturer in Mechanical Engineering Department of PUT

INTERESTS:

- Technology planning
- CAD/CAM in Manufacturing Systems
- Enterprise Logistics
- Vision Systems in Manufacturing Processes
- Rapid Prototyping techniques in Manufacturing

Experience (projects):

BRIGHT

- Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period

EMERALD

- European network for 3D printing of biomimetic mechatronic systems

MSc. Eng. Natalia WIERZBICKA, PhD student

Faculty of Mechanical Engineering
Institute of Mechanical Technology
Department of Technology Design

Completed higher education:
Biomedical Engineering - Poznań University of Technology,
Faculty of Mechanical Engineering

Topic of doctoral dissertation:
Tribological properties of polymer- and silicone-based composites with inorganic additives

Position – Assistent in Technology Department of PUT

INTERESTS:

- Tribology
- CAD/CAM in Manufacturing Systems
- Rapid Prototyping techniques in Manufacturing
- Robotics
- Biomedical Engineering

Experience (projects):

BRIGHT

- Boosting the scientific excellence and innovation capacity of 3D printing methods in pandemic period

EMERALD

- European network for 3D printing of biomimetic mechatronic systems

Polish Biomedical Engineering Conference (PBME)

The event when we create a space for dialogue among students, doctoral candidates, scientists, doctors, physiotherapists, industry, and entrepreneurs who are united by the incredibly dynamically developing field of biomedical engineering.

pbme-conf.put.poznan.pl

List of publications from the last 3 years. The total score is 15 items.

1. The friction of the composite based on polyethylene with inorganic additives/ **Natalia Wierzbicka** (WIM), Rafał Talar (WIM), Karol Grochalski (WIM), Adam Piasecki (WIMiFT), Miłosz Węgorzewski and Adam Reiter // Materials – 2023 (140pkt)
2. Influence of dispersed phase content on the mechanical properties of electroless nanocomposite Ni-P/Si3N4 and hybrid Ni-P/Si3N4/graphite layers deposited on the AW-7075 alloy/ Kazimierz Czapczyk, Paweł Zawadzki (WIM), **Natalia Wierzbicka** (WIM) //Applied Surface Science (140pkt)
3. Tribological properties of hardened surfaces constituted by various methods of mechanical processing / Paweł Zawadzki (WIM), **Natalia Wierzbicka** (WIM), Rafał Talar (WIM), Łukasz Burysz //TRIBOLOGIA - 2021, vol. 298, no. 4, s. 57-72 (70pkt)
4. The Friction of Structurally Modified Isotactic Polypropylene / **Natalia Wierzbicka** (WIM), Tomasz Sterzyński, and Marek Nowicki (WIMiFT)// Materials - 2021, vol. 16, no. 15 (140pkt)
5. Microstructure and Properties of Electroless Ni-P/Si3N4 Nanocomposite Coatings Deposited on the AW-7075 Aluminum Alloy / Kazimierz Czapczyk, Paweł Zawadzki (WIM), **Natalia Wierzbicka** (WIM), Rafał Talar (WIM) // Materials - 2021, vol. 14, no. 16 (140pkt)
6. Evaluation of deterioration of engine oil properties in the function of mileage / **Natalia Wierzbicka** (WIM), Dominika Szadkowska, Adam Patalas (WIM), Rafał Talar (WIM), Remigiusz Łabudzki (WIM), Paweł Zawadzki (WIM) // Journal of Physics: Conference Series - 2020, vol. 1426 (40pkt)
7. The construction of an automated bicycle parking / Remigiusz Łabudzki (WIM), Rafał Talar (WIM), Paweł Zawadzki (WIM), Adam Patalas (WIM), **Natalia Wierzbicka** (WIM), Dominika Szadkowska // Journal of Physics: Conference Series - 2020, vol. 1426 (40pkt)

In my free time:

P.hD. Eng. Adam Patalas

E-mail: adam.patalas@put.poznan.pl

Institute of Mechanical Technology

Mechanical Engineering Faculty

Poznan University of Technology

Education:

2016/06 – 2022/06 Warsaw University of Technology, PhD, Faculty of Mechatronics, **Biomedical Engineering Discipline**
2015/10 – 2020/09 Poznań University of Technology, PhD studies, 3rd cycle studies
2014/03 – 2015/06 Poznań University of Technology, **Mechatronics**, 2nd cycle, master's studies (specialization: Mechatronic Structures),
2011/10 – 2015/02 Poznań University of Technology, **Biomedical Engineering**, First-cycle engineering studies,
2010/10 – 2014/02 Poznań University of Technology, **Materials Engineering**, First-cycle studies, engineering

Experience (projects):

Currently – from 2015/10 – Poznań University of Technology – Scientific and teaching assistant at the Technology Design Department: Responsible for the following subjects: Spine and limb prosthetics, Computer-Aided Technology.

Currently – from 2019/04 - ENforce Medical Technologies Sp. z o.o. – Technologist - Tasks: Development of a vacuum prosthetic socket intended for use with a foot prosthesis; A prototype of a bionic foot and miniaturized conceptual versions of MR dampers were developed; Development, implementation and validation of a stand for determining the characteristics of MR dampers.

2017/09 – 2015/10 - Casimir the Great University in Bydgoszcz - Assistant at the Institute of Technology, conducting project classes and seminars on the following subjects: Basics of medical bioengineering, also running laboratories on: Elements of mechatronics, Electrical engineering and electronics, Automation and robotics.

Manager of tribological laboratory

Our device:

- Anton Paar step 700 with the micro-tribo tester MCT³ and the nano-scratch tester NST³
- Brucker UMT Tribometr
- Alemnis In-Sem Mechanical tester
- Fischer Picodentor HM500
- Fischer XRF Spectrometer
- Brookfield Viscometer
- Adhesion tester Positest AT-A
- Microhardness tester FM-700
- 3 original tribology testers

List of publications from the last 2 years. The total score is 33 items.

1. Swathi Raghu, Patrick Hartwich, **Adam Patalas**, Mateusz Marczewski, Rafał Talar, Christian Pritzel, Manuela S. Killian. 2023. Nanodentistry aspects explored towards nanostructured ZrO2: Immobilizing zirconium-oxide nanotube coatings onto zirconia ceramic implant surfaces Open Ceramics - 2023, vol. 14, s. 100340-1-100340-6
2. Wojciech Smułek, Maria Ratajczak, **Adam Patalas**, Adam Voelkel, Ewa Kaczorek, Mariusz Sandomierski. 2023. Agar composites containing Zinc zeolite infused with Quillaja saponins exhibit improved structural properties and anti-Candida activity Environmental Technology & Innovation - 2023, vol. 32, s. 103278-1-103278-10
3. Paweł Zawadzki, **Adam Patalas**, Remigiusz Łabudzki, Rafał Talar. 2023. Measurement of thermal conductivity of the cortical bone: experimental studies and comparative analysis Journal of Physics: Conference Series - 2023, vol. 2540, s. 012035-1-012035-9
4. Zuzanna Buchwald, Mariusz Sandomierski, Wojciech Smułek, Maria Ratajczak, **Adam Patalas**, Ewa Kaczorek, Adam Voelkel. 2023. Physical–chemical and biological properties of novel resin-based composites for dental applications Polymer Bulletin - 2023, vol. 80, iss. 10, s. 11249-11272
5. Mariusz Sandomierski, Wiktoria Stachowicz, **Adam Patalas,** Karol Grochalski, Wiesław Graboń, Adam Voelkel. 2023. Characterization of Magnesium and Zinc Forms of Sodalite Coatings on Ti6Al4V ELI for Potential Application in the Release of Drugs for Osteoporosis. Materials, vol. 16, iss. 4, s. 1710-1-1710-17 (**IF: 3,62**)
6. Mariusz Sandomierski, Monika Zielińska, Katarzyna Adamska, **Adam Patalas**, Adam Voelkel. 2022. Calcium montmorillonite as a potential carrier in the release of bisphosphonates. New Journal of Chemistry - vol. 46, iss. 7, s. 3401-3408 **(IF: 3,59)**
7. Mariusz Sandomierski , Monika Zielińska, Tomasz Buchwald**, Adam Patalas**, Adam Voelkel. 2022. Controlled release of the drug for osteoporosis from the surface of titanium implants coated with calcium titanate. Journal of Biomedical Materials Research Part B, vol. 110, iss. 2, s. 431-437 **(IF:3,37**)
8. Paweł Zawadzki, Rafał Talar, **Adam Patalas**, Stanisław Legutko. 2022. Influence of Machining Parameters on Cutting and Chip-Formation Process during Cortical Bone Orthogonal Machining. Materials, vol. 15, iss. 18, s. 6414-1-6414-24 (**IF: 3,62**)

MSc. Eng. Paweł Zawadzki, PhD student

Faculty of Mechanical Engineering
Institute of Mechanical Technology
Department of Technology Design

Completed higher education:
Biomedical Engineering - Poznań University of Technology, Faculty of Mechanical Engineering

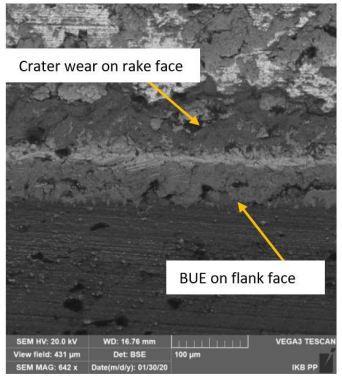
Topic of doctoral dissertation:
A method for precise shaping of bone surfaces

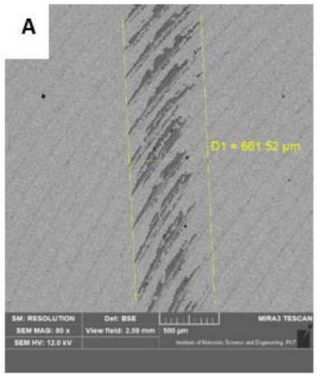
SCIENTIFIC INTERESTS

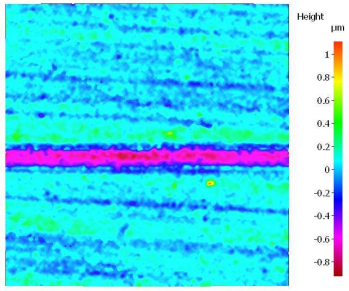
Biomedical engineering: design of implants and endoprostheses, development of surgical equipment

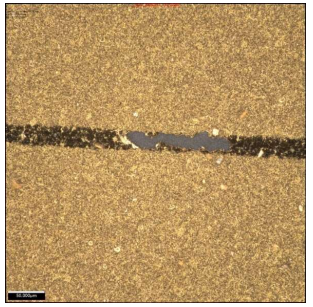
Machining: biomaterials processing, hard and soft tissue processing, wear of cutting tools

Tribology: biotribology, biomimetics in tribological issues, micro and nanotribology, surface engineering







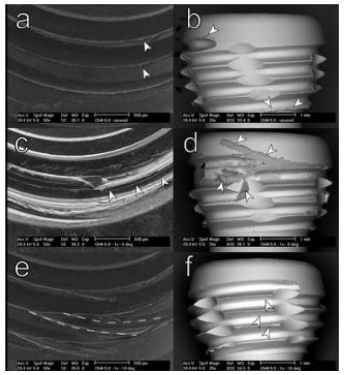


Scientific articles published in journals such as:

- WEAR
- Scientific Reports
- Journal of Orthopedic Trauma
- PLOS ONE
- Veterinary and Comparative Orthopedics and Traumatology
- Materials
- Journal of Functional Biomaterials

Patents:

- endoprostheses
- surgical instrumentation



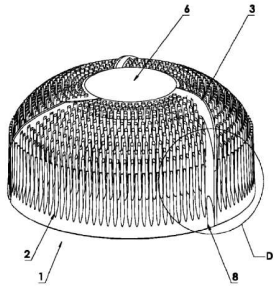
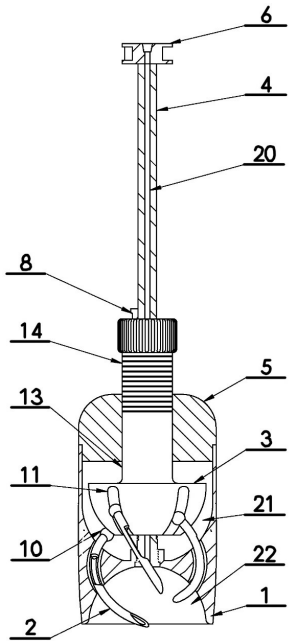


Fig. 5



Polish folk traditions

Production of traditional folk instruments: greater poland bagpipes, violins, drums and basses.

Msc Eng. Jakub Gapsa

PhD Student / Junior Unity Developer

Member of the team working on VR technologies at
Poznan University of Technology,
PhD student at PP Doctoral School (2nd year)
– Faculty of Mechanical Engineering

Experience (projects):

- Contractor in the project "Flexible system for increasing the competences of technical service employees using virtual reality techniques" (beneficiary: Enea Operator) - project completed with the implementation of the system
- VR specialist in the project "Innowacyjne kształcenie elektryków dostosowane do branży energetycznej" (Component Ill, Institutional cooperation for improving the quality and relevance of vocational education and training (VET) and continuing education, beneficiary: CKZiU Elektryk Nowa Sól) - project completed with implementation of the system
- VR specialist - building the Avatar Scoliosis 3D application in the project "Longitudinal assessment of changes in psychosocial functioning of patients with adolescent idiopathic scoliosis before, during and after treatment. A quantitative and qualitative study." (National Science Center, beneficiary: Medical University of Poznan), an activity completed with the implementation of an application for the study of patients in an orthopedic hospital

“Scoliosis 3D” - A Virtual-Reality-Based Methodology Aiming to Examine AIS Females’ Body Image

https://doi.org/10.3390/app13042374

VR specialist, conducting classes and trainings for students of technical schools, in the measure "Czas zawodowców BIS-zawodowa Wielkopolska"

In my free time:

- board games
- fantasy books
- disc golf

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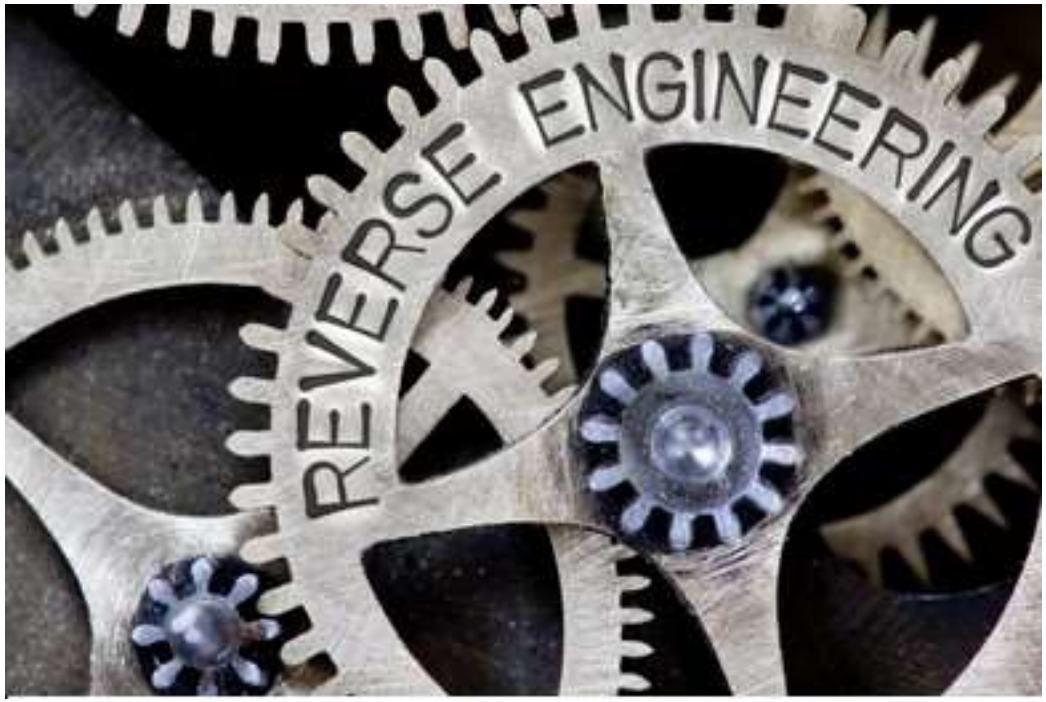
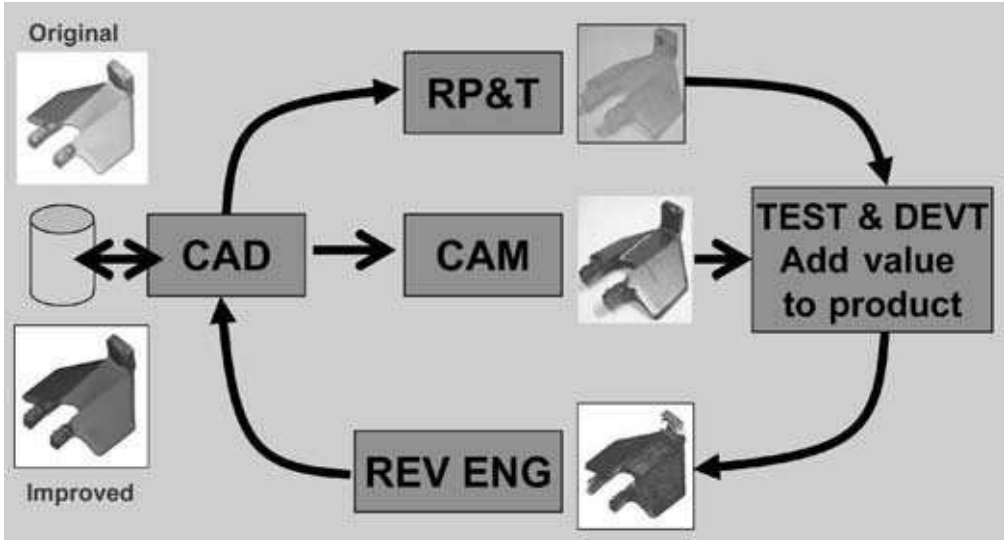
European Network for Additive Manufacturing in Industrial Design for Ukrainian Context Contextternational S.A., Madrid, Spain, 7-10 May 2024

IO1 - EMERALD e-book for industrial design for complex parts



Reverse engineering - basics

Reverse engineering (RE) is now considered one of the technologies that provide business benefits in shortening the product development cycle.

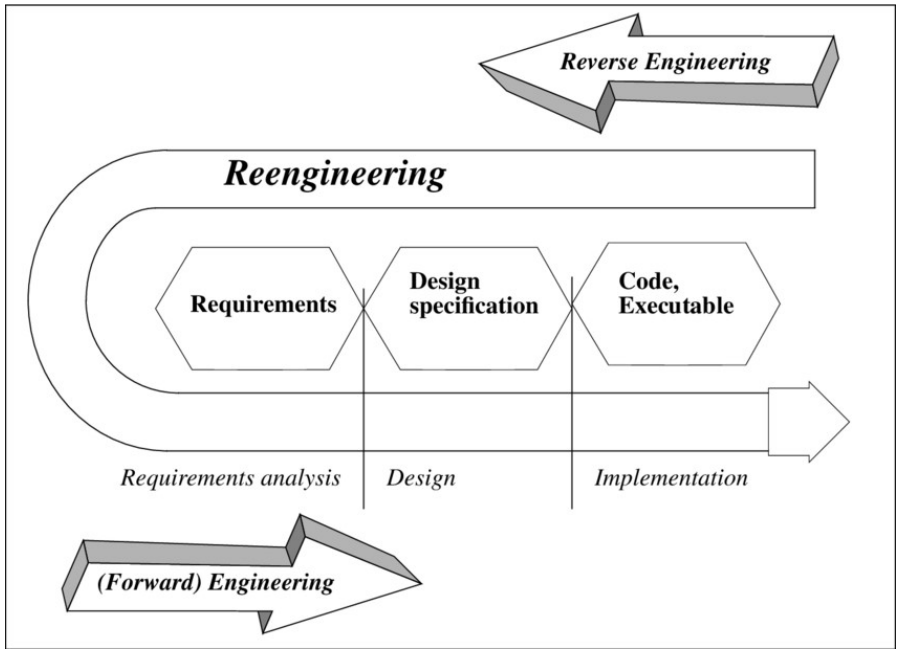


Product development cycle

Figure depicts how RE allows the possibilities of closing the loop between what is “as designed” and what is “actually manufactured”.

Reverse engineering - basics

There are two types of engineering: forward engineering (FE) and reverse engineering (RE). Forward engineering (FE) is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system. In some situations, there may be a physical part/product without any technical details, such as drawings, bills-of-material, or without engineering data



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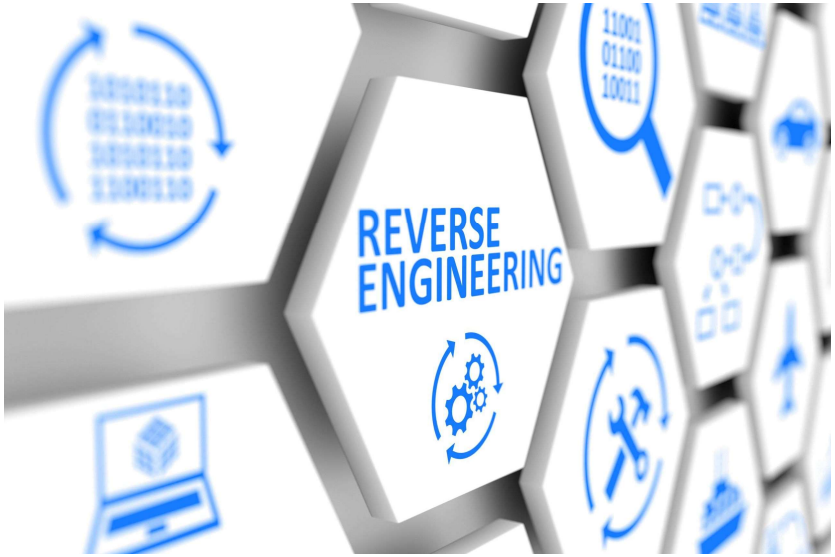
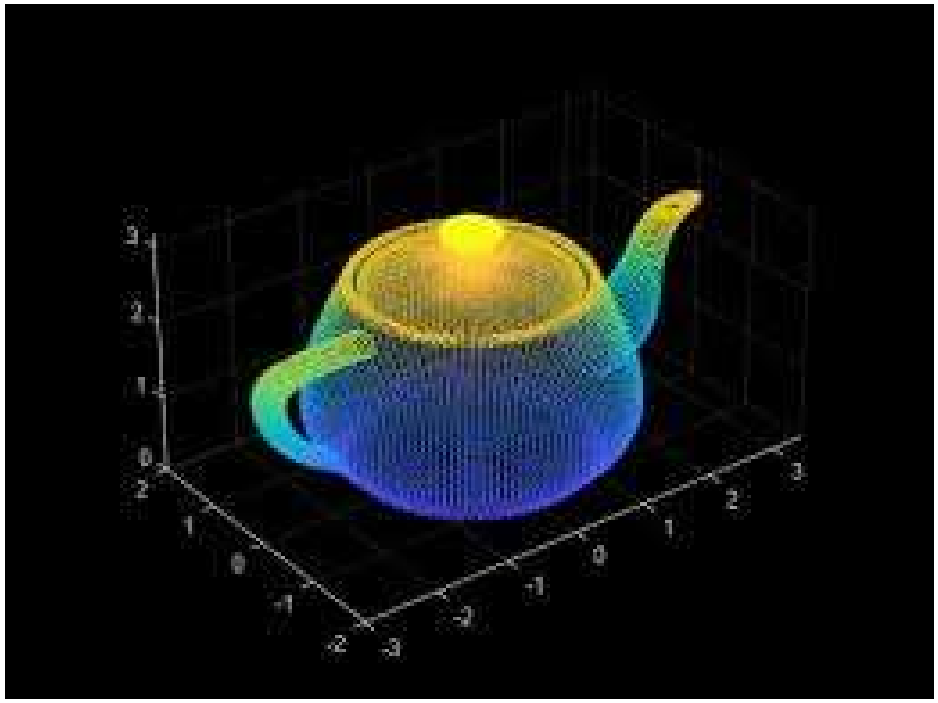
Reverse engineering - basics

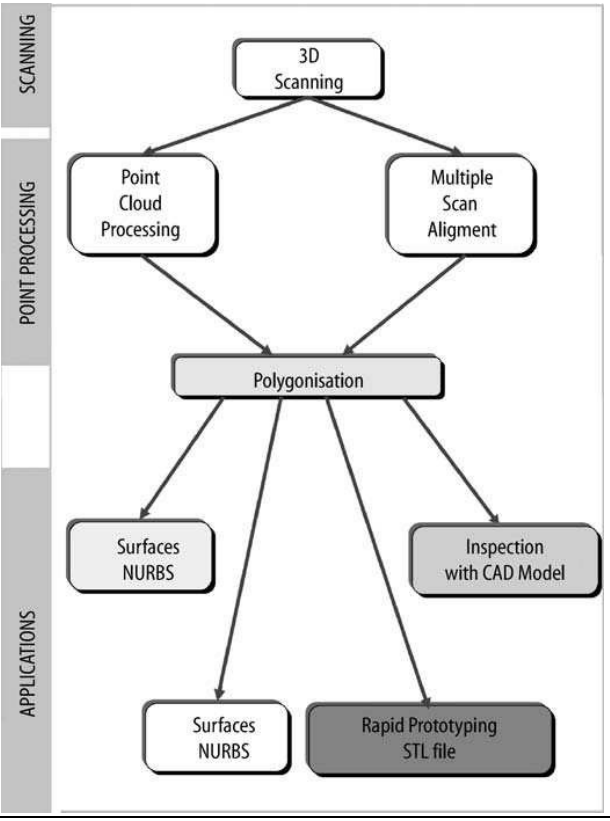


The process of duplicating an existing part, subassembly, or product, without drawings, documentation, or a computer model is known as reverse engineering (RE).

Reverse engineering - basics

Reverse engineering is also defined as the process of obtaining a geometric CAD model from 3-D points acquired by scanning/digitizing existing parts/products. The process of digitally capturing the physical entities of a component, referred to as reverse engineering (RE), is often defined by researchers with respect to their specific task.





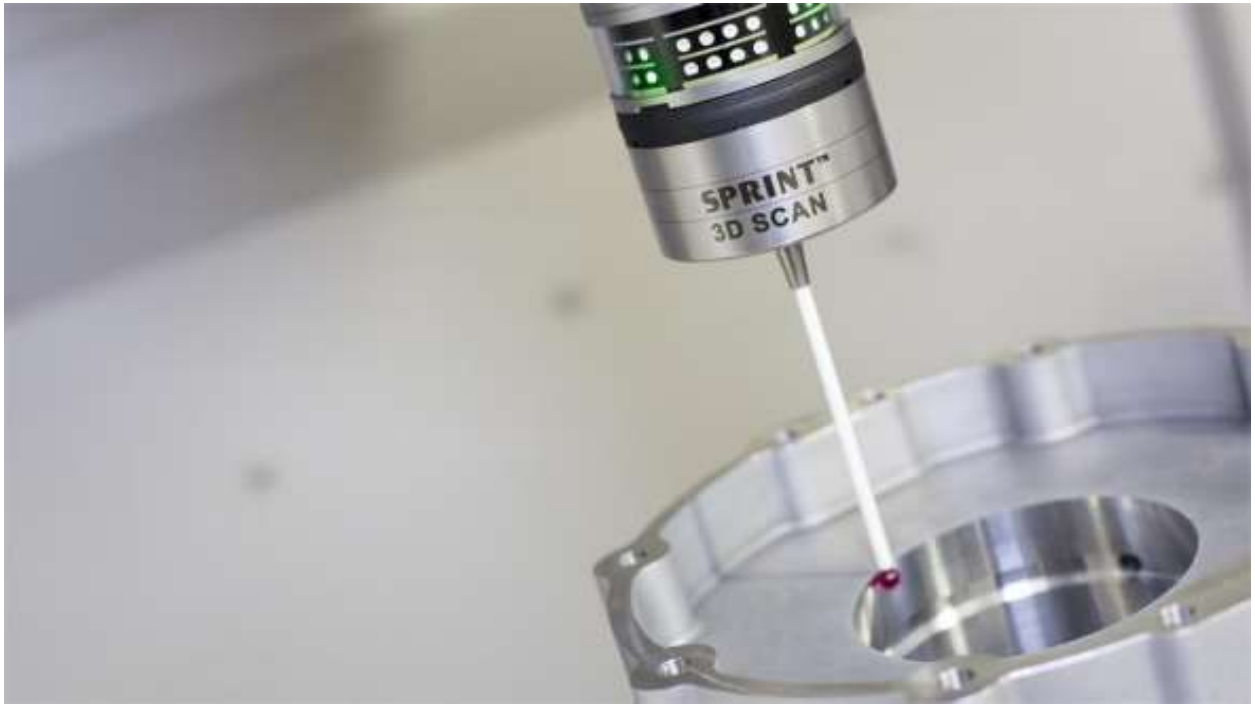
Reverse engineering – generic process

Phase 1 – Scanning

Phase 2 – Point Processing

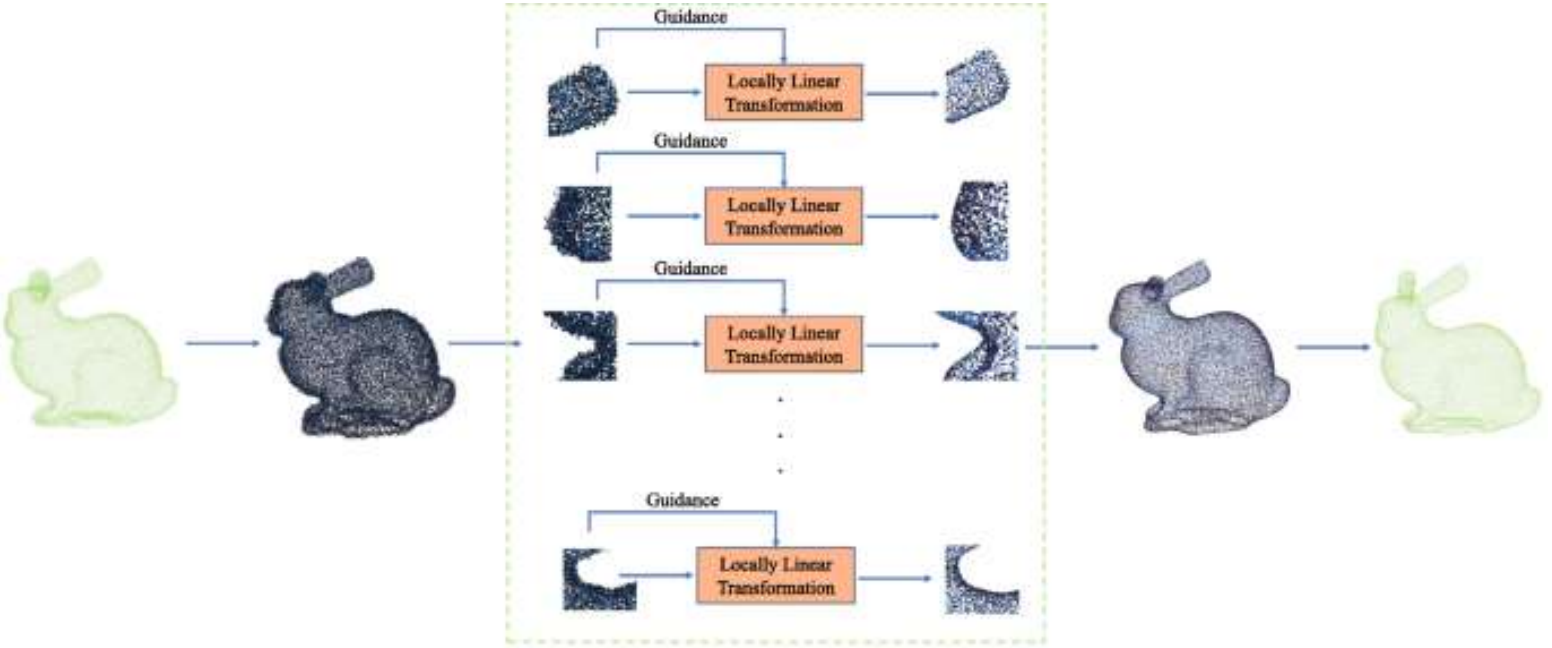
Phase 3 – Application Geometric Model Development

Reverse engineering – contact scanning

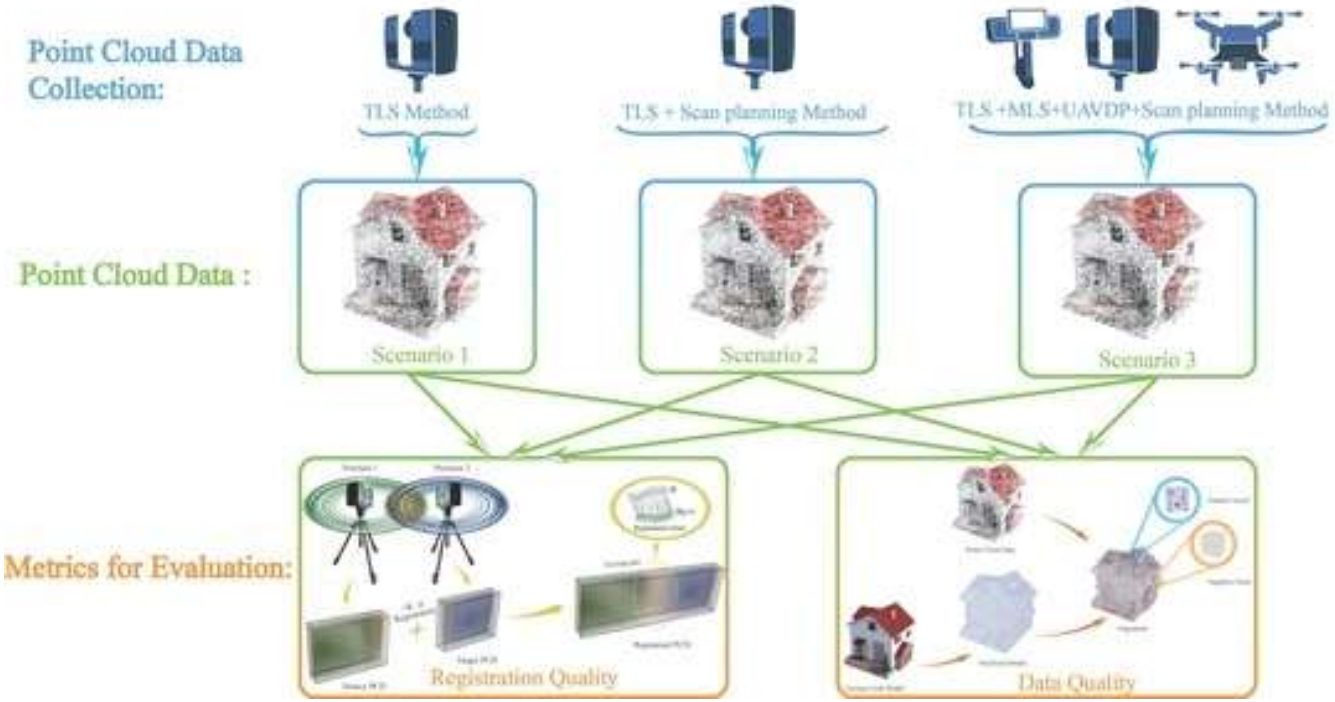


Reverse engineering – optical scanning

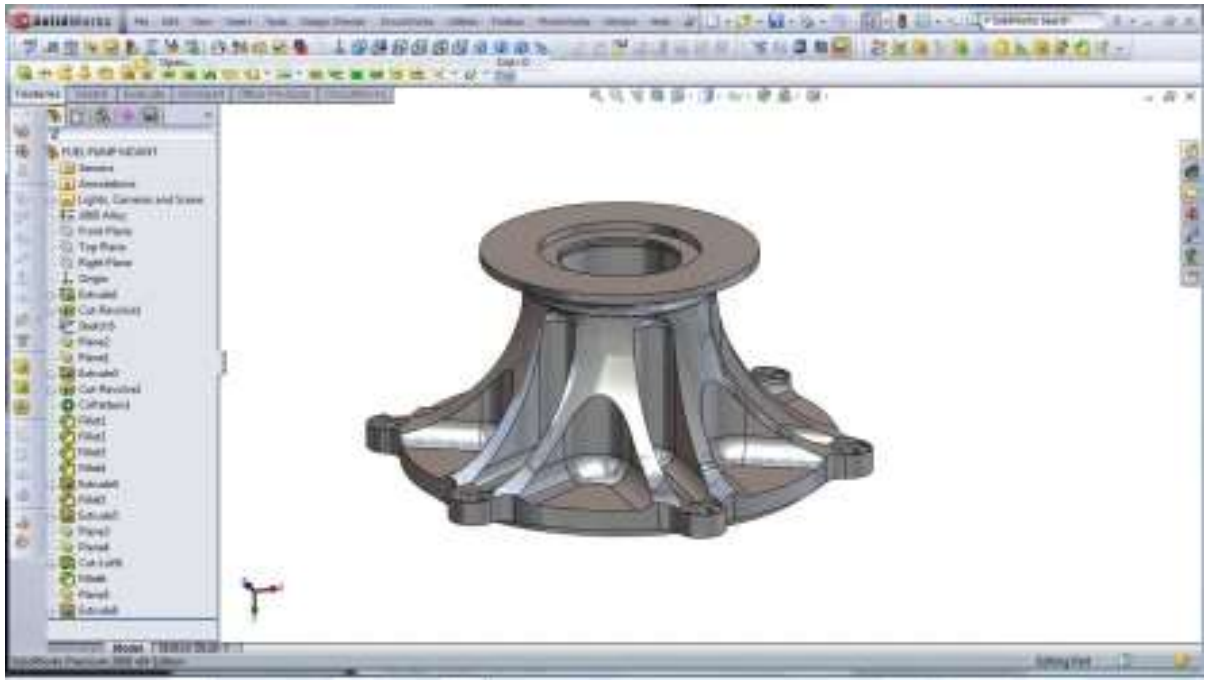
Reverse engineering – point processing



Reverse engineering – Multiple Scan Planning in architecture



Reverse engineering – Geometric Model Development



The output of this phase is geometric model in one of the proprietary formats such as IGES, VDA, STL, DXF, OBJ, VRML, ISO G

Applications of reverse engineering

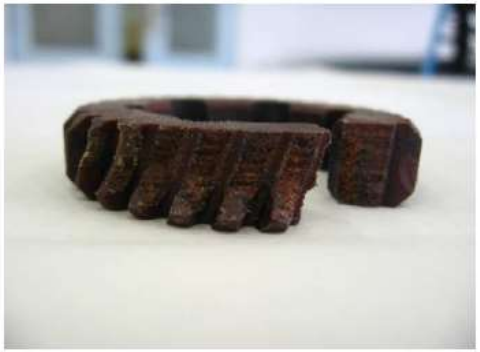
Reverse engineering is justified to be used primarily where there is a need to duplicate the structure of an object that already physically exists. However, it is used when there is no form of recording the structure of an existing object that could constitute the basis for its production.

- *Applications in Mechanical Industries*
- *Applications in Medical Life Sciences*
- *Applications in Software Industries*
- *Applications in Film Entertainment or Animation Industry*

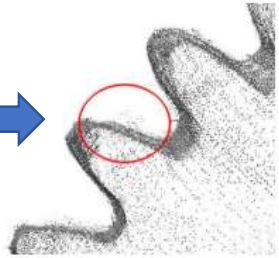
- *Applications in Mechanical Industries*

✓ Digital documentation
✓ Modification and improvement of existing designs
✓ Analysis and optimization
✓ Prototyping and manufacturing
✓ Repair and regeneration
✓ Customization and personalization
✓ Benchmarking and competitor analysis
✓ Innovation and improvements
✓ Intellectual property protection
✓ Failure analysis
✓ Materials and process research
✓ Development of new methods and tools

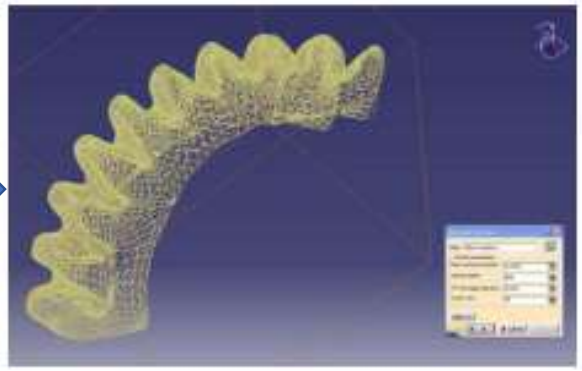
- The article "Application of reverse engineering techniques in mechanics system services" by Michal Dúbravþík and Štefan Kender



Damaged component – gear-wheel



Model of 3D scanning with inaccuracy

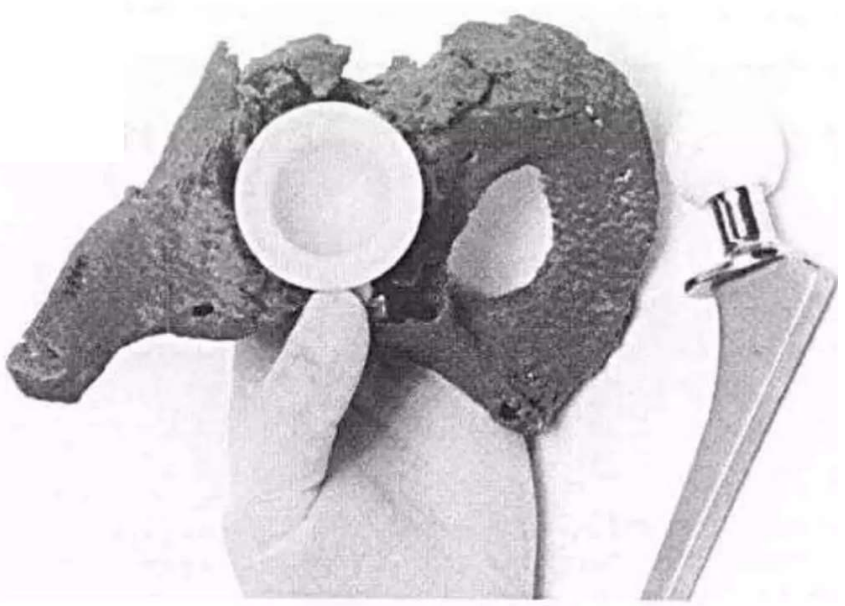


Mesh of a gear wheel part

New gear wheel made from ULTEM 9085

- *Applications in Medical Life Sciences*

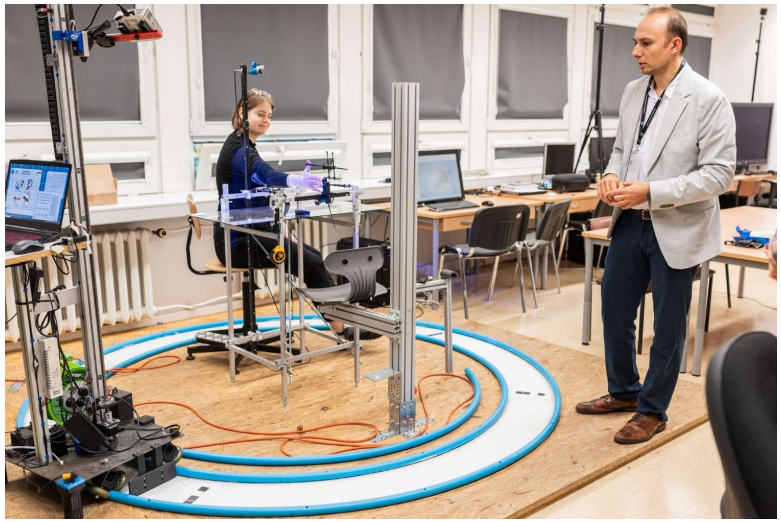
✓ Understanding existing device design and functionality
✓ Developing new and improved medical devices
✓ Creating patient-specific implants and prosthetics
✓ Reconstructing complex biological structures
✓ Developing biocompatible materials
✓ Understanding drug delivery mechanisms
✓ Drug discovery and development
✓ Understanding device functionality for repairs
✓ Analyzing and reconstructing fractured bones
✓ Creating educational and training materials



Completed model with acetabular cup and femoral component to give scale.

AutoMedPrint

The prototype AutoMedPrint system developed at the Poznań University of Technology is used for quick, automatic design and production of limb prostheses and orthoses using 3D printing, mainly for children.



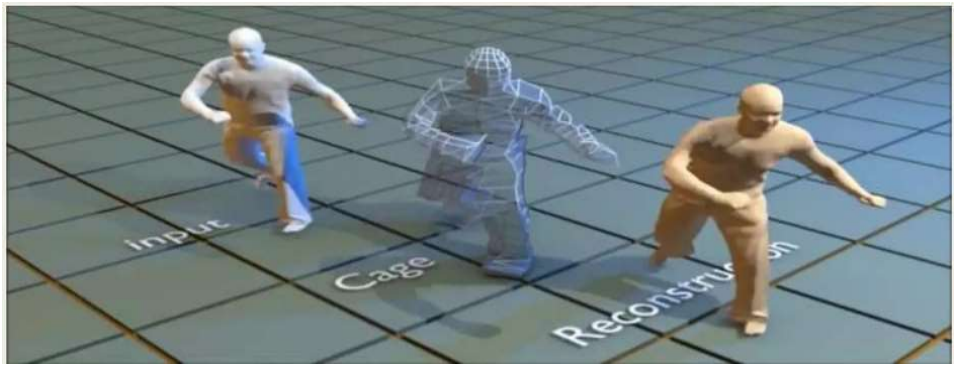
This is done using a 3D scanner on a specially constructed station, at a fraction of the cost of traditionally produced equipment.

- *Applications in Software Industries*

✓ Recovering Lost or Corrupted Data
✓ Understanding Legacy Code and Systems
✓ Identifying Security Vulnerabilities
✓ Creating Compatible Software with Existing Systems
✓ Migrating Software to New Platforms or Technologies
✓ Debugging Complex Software Issues
✓ Improving Software Performance and Efficiency
✓ Creating Educational and Training Materials

- *Applications in Film Entertainment or Animation Industry*

In the film entertainment or animation industry, reverse engineering provides several advantages. It animates objects using reverse-engineered human skeletons, performs 3D scanning for rapid surfacing of scale models, supports online marketing and presentations, and brings real-life forms into the virtual gaming industry.



THANK YOU FOR YOUR ATTENTION ☺