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Conference schedule

Meet Link https://meet.google.com/iqz-qfun-yap

2 October, 2024

12:00 Eastern European Summer Time (EEST)

Time	Speaker	Title of Speech
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12:05	Uminurida Suciati, Universitas Gadjah Mada, Indonesia	USER EXPECTATIONS AND SERVICE DELIVERY IN THE UGM LIBRARY'S REFERENCE AND PERIODICAL PUBLICATION SERVICES: A QUALITATIVE ANALYSIS
12:12	Fauzan Hidayatullah, Universitas Hasanuddin, Indonesia	THE INFLUENCE OF TECHNOLOGICAL DEVELOPMENT ON CONSUMER BEHAVIOR: A QUALITATIVE STUDY OF ONLINE SHOPPING PLATFORMS
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ASYMPTOTICALLY CONSISTENT MORPHOELASTIC SHELL MODEL FOR BIOLOGICAL TISSUES

Xiang Yu, Dongguan University of Technology, Guangdong, China

We derive an asymptotically consistent morphoelastic shell model to describe the finite deformations of biological tissues using the variational asymptotic method. Biological materials may exhibit remarkable compressibility when under large deformations, and we take this factor into account for accurate predictions of their morphoelastic changes. The morphoelastic shell model combines the growth model of Rodriguez et al. and a novel shell model developed by us. We start from the three-dimensional (3D) morphoelastic model and construct the optimal shell energy based on a series expansion around the middle surface. A two-step variational method is applied that retains the leading-order expansion coefficient while eliminating the higher-order ones. The main outcome is a two-dimensional (2D) shell energy depending on the stretching and bending strains of the middle surface. The derived morphoelastic shell model is asymptotically consistent with three-dimensional morphoelasticity and can recover various shell models in literature. Several examples are shown for the verification and illustration.

Introduction

Many biological systems are shell-like structures with one dimension much smaller than the other two, for example, the leaves of the Utricularia (bladderworts) and the Venus flytrap, the triangular pectoral fins of manta rays, the tympanic membranes of our ears, and fetal membranes of embryos;

see Fig. 1. One feature of biological systems is that they grow to adapt to the environment, which is important for their normal functioning. As shown in Fig. 1, the bladderworts capture the prey by quickly expanding their leaves to generate a flow to suck the prey in; the Venus flytrap captures insects by fast changing the curvature of its leaves; the manta ray swims with the large bending of its pectoral fins; the tympanic membrane separates our inner and outer ears and transmits the sound from the air to our middle ear through finite deformations, and the fetal membrane undergoes large deformations as the embryo develops throughout the pregnancy period. To better understand the mechanism under the large deformations of various thin biological shells, a morphoelastic shell theory with wide applicability needs to be developed.

By incorporating the growth effects, Dervaux and Ben Amar (2008) and Dervaux et al. (2009) derived the generalized Foppl□von Karman theory of thin plates under the membrane assumption. As applications, they studied the morphogenesis of Acetabularia algae and grass blades through linear bifurcation analysis. This morphoelastic plate theory was also adopted by Xu et al. (2020) to study the patterns of lotus leaves, which can either be local wrinkles with short wavelength at the edge or the global bending cone with long rippled waves near the edge. The water as a substrate was shown to be the main contributor to this difference. The Foppl□von Karman plate theory of growth was later improved by Wang and coworkers (Wang et al., 2018; Li et al., 2022; Du et al., 2023a, 2023b) to account for finite-strain deformations. They started from a series expansion of the displacement without ad hoc assumptions. Then through asymptotically consistent manipulation of the three-dimensional governing system, plate equations were derived. The boundary conditions were proposed separately. Following similar ideas, Li

et al. (2023) constructed a shell theory incorporating the growth effects for incompressible materials. Another morphoelastic shell model was established by Haas and Goldstein (2021) to account for the large bending of the incompressible cell sheet. Proper scaling for the intrinsic curvature was introduced and asymptotic expansion of the energy was implemented to derive the shell theory in the limit of thin shells. Yin et al. (2022) developed a chemomechanical framework for active shells, incorporating both biochemical and mechanical factors, which successfully accounts for the mechanical feedback on cellular chemical patterns. Their framework employs Koiters shell theory, suitable for analyzing deformations with large rotations but small strains.

Apart from the continuum models, some discrete computational models are also obtained to describe the mechanics of the growing thin membranes and shells. Rausch and Kuhl (2014) derived a finite element model to describe the growing biological membranes using discrete Kirchhoff shell kinematics. By applying this model, they demonstrated the chronic adaptation of the leaflet membrane under pathological loading conditions. Rudraraju et al. (2019) constructed a three-dimensional computational framework coupling morphology, incremental surface growth by accretion, and morphoelastic volume growth to study the shape evolution of mollusk shells.

Model Derivation

Three-Dimensional Morphoelastic Model

The three-dimensional morphoelasticity problem is introduced in this section, and for easier reading, some knowledge of shell geometry is first reviewed.

Two-Dimensional Morphoelastic Shell Model

In this section, we derive an asymptotically consistent two-dimensional morphoelastic shell model from the three-dimensional model formulated in Section 2. The asymptotic derivation builds on two main ingredients: one is an asymptotic expansion method, and the other is a two-step variational method.

Connection with Other Reduced Models

In this section, we show that our morphoelastic shell model recovers other reduced models in literature. By applying the correct scaling assumptions, we can derive the classical Kirchhoff and Foppl□von Karman shell theories from our more comprehensive model. Our shell model is also consistent with the finite-strain shell model of Song and Dai (2016) that is derived from the three-dimensional differential equations. Besides, in the plane strain case for the localized necking, our shell model.

Results and Discussion

We now proceed with the results obtained from the two-dimensional shell model. Several applications are discussed, and benchmark problems with exact solutions are solved for verification.

Conclusion

In this paper, we have derived an asymptotically consistent morphoelastic shell model for biological tissues under finite deformations, considering both geometric and material nonlinearities. This model captures both stretching and bending effects, and retains the variational structure for numerical simulations. It can be applied under general loading conditions and is shown to be consistent with various classical shell models.

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FREE RADICALS IN BODIPY CHEMISTRY

Olena Kovtun, Dragomanov Ukrainian State University

Free radicals are highly reactive atomic or molecular particles characterized by an unpaired electron on an outer orbital. These species can either be neutral or carry a positive or negative charge, and their classification depends on the orbital the unpaired electron occupies. For instance, π-radicals (like phenylmethyl radicals) involve π-orbitals, while σ-radicals (such as phenyl radicals) involve σ-orbitals. The central atom, where the highest spin density is localized, further classifies radicals into carbon-centered (C·), oxygen-centered (O·), or nitrogen-centered (N·) radicals. The radical center is the atom where the unpaired electron predominantly resides, giving rise to classifications such as C-centered or O-centered

radicals, though these names can be somewhat arbitrary in delocalized systems.

The discovery of free radicals marked a significant milestone in organic chemistry, with the first organic radical, triphenylmethyl radical, being identified by Moses Gomberg in 1900 at the University of Michigan. Free radicals can form under various conditions such as heat, ultraviolet radiation, or other energetic interactions with molecules. A notable characteristic of radicals is their high reactivity, driven by the presence of an unpaired electron. Due to their fleeting nature, radicals often have short lifespans, typically lasting only milliseconds. Despite their transient existence, radicals play vital roles in biological systems, participating in enzymatic reactions and processes like oxidative stress and immune defense.

In living organisms, free radicals contribute to numerous biological processes, including the oxidation of nucleic acids, proteins, and lipids. These radicals, such as superoxide anion and hydroxyl radical, are formed in biological systems through the reduction of oxygen. While these radicals can help destroy pathogens, excessive concentrations can harm the organism, leading to cellular damage and diseases like cancer, stroke, myocardial infarction, and diabetes. The role of free radicals is also evident in aging and neurodegenerative diseases, such as atherosclerosis, Parkinson's disease, Alzheimer's disease, and even conditions like schizophrenia and hearing loss caused by aging or medications.

Organisms produce several enzymes to combat free radical damage, such as superoxide dismutase, catalase, glutathione peroxidase, and glutathione reductase. Non-enzymatic antioxidants like vitamins A, C, and E, along with polyphenols and coenzyme Q10, also play crucial roles in neutralizing free radicals. These protective mechanisms are essential in

maintaining cellular health and preventing damage caused by oxidative stress. However, in industrial chemistry, radicals are utilized for their high reactivity. They are important in heterogeneous catalysis, rapid oxidation processes like combustion, and various intermediate reactions in cracking, pyrolysis, and polymerization.

The study of radicals has expanded into various fields of organic chemistry, including the chemistry of dyes. Recent research highlights the involvement of radical intermediates in reactions involving BODIPY dyes (boron-dipyrromethene compounds). These dyes, known for their stability and bright fluorescence, are extensively used in fields like bioimaging and photodynamic therapy. The formation of radicals plays a crucial role in several transformations of BODIPY derivatives, where heat can induce the homolytic cleavage of bonds, leading to the formation of stable radical intermediates. These radicals can further dimerize to form dimeric molecules, a reaction whose products are confirmed using chemical and physicochemical methods.

The synthesis and study of substituted BODIPY compounds have revealed interesting radical-based mechanisms. For instance, heating BODIPY derivatives can break bonds homogeneously, producing relatively stable radical intermediates. These intermediates, once formed, undergo dimerization, resulting in dimer molecules, a process supported by experimental data. Further research employing advanced physicochemical methods is required to fully confirm the radical formation and the detailed mechanisms underlying these reactions.

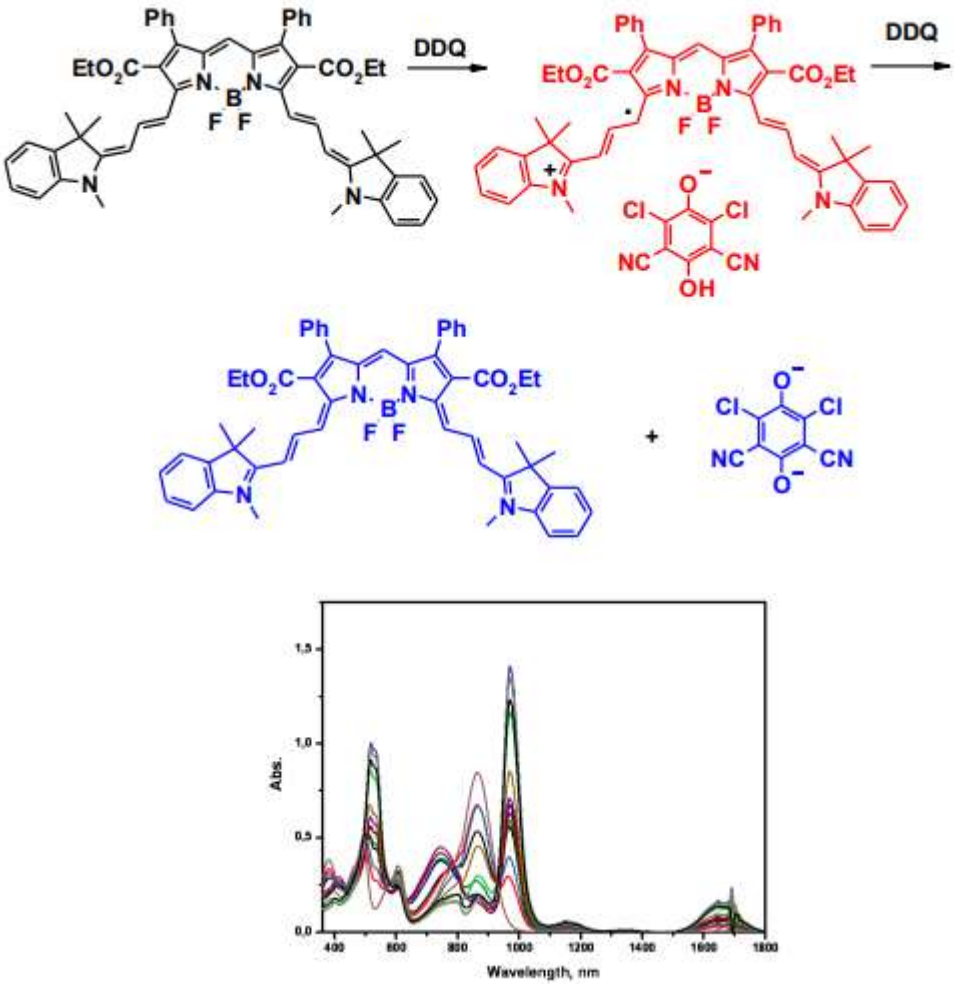

Fig.1. Radical cation and dilidene based on borodipyrromethenocyanidine

In conclusion, free radicals play an essential role in both biological and chemical systems. From their discovery in organic chemistry to their role in modern industrial processes and biological functions, free radicals remain a topic of great scientific interest. In particular, the role of radicals in the transformations of BODIPY dyes provides valuable insights into radical-based reactions and opens new avenues for research in dye chemistry. Further studies will continue to explore the implications of radical chemistry in various fields, enhancing our understanding of these highly reactive species.

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CHEMICAL ASPECTS OF THE MAIN CARBON CYCLE PATHWAYS

Victoria Bogatyrenko, Dragomanov Ukrainian State University

Carbon (C) is a chemical element that forms minerals and rocks, classified as carbonates on Earth, and a wide variety of organic compounds in the biosphere, such as CO, CO_2, hydrocarbons (CH_4, C_2H_4, C_2H_6, etc.) and their derivatives. Carbon can exist in various phases (solid, liquid, gaseous) within the biosphere, forming a dynamic system influenced by

both natural and anthropogenic factors. As an active migratory element in air and water, carbon plays a vital role in Earth's ecosystems.

The combination of continuous, periodic, and cyclical processes of transformation, movement, distribution, dissipation, and concentration of carbon in the biosphere, pedosphere, hydrosphere, and atmosphere constitutes the global carbon cycle. In this global cycle, the carbon balance is determined by various biogeochemical cycles, each accounting for the intake and release of CO_2 (carbon dioxide), the most mobile form of carbon in the biosphere, as well as long-term carbon sequestration in the form of deposits and fossil fuels.

Introduction

The current atmosphere contains approximately 2.3×10^{12} tons of CO_2, with concentrations having increased by 20% over the past century. CO_2's role in the atmosphere is due to its unique physicochemical properties: like glass in a greenhouse, CO_2 allows shortwave solar radiation to pass but traps the thermal radiation emitted by the Earth's surface, causing the greenhouse effect. The thicker the CO_2 layer, the more likely the Earth's surface will overheat. However, predictive models of greenhouse gas accumulation (CO_2 and water vapor, H_2O) suggest higher heating effects than what is observed in reality, explained by the Earth's natural system aimed at maintaining a stable CO_2 level.

Natural Regulation of CO_2 Concentration

The natural regulation mechanism of atmospheric CO_2 is complex and largely depends on the reversible chemical reactions in the "atmosphere-hydrosphere" system, influenced by environmental physicochemical conditions. The quantitative relationships of these reactions can be estimated using Le Chatelier's principle. CO_2 absorption by the ocean surface, forming

water-soluble bicarbonates, plays a significant role in water hardness and leads to the formation of carbonate deposits (limestones, dolomites, aragonites, coral reefs).

When atmospheric CO_2 concentration reaches 0.03%, a partial pressure of 3039 Pa is achieved, enabling the equilibrium process of gas dissolution in ocean water, as shown by the reaction:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

Increased atmospheric CO_2 partial pressure enhances CO_2 solubility in oceanic surface waters, forming carbonic acid (H_2CO_3), which dissociates according to the equations:

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

$$HCO_3^- \rightleftharpoons H^+ + CO_3^{2-}$$

The dissociation constants are $K_a1 = 4.5 \times 10^{-7}$ and $K_a2 = 4.68 \times 10^{-11}$, indicating that the primary source of oceanic CO_2 is the atmosphere. The ocean contains 60 times more dissolved CO_2 than the atmosphere, and bicarbonate ion concentration is directly proportional to atmospheric CO_2 solubility.

Processes in the Hydrosphere and Lithosphere

In the ocean, lower layers are saturated with H_2CO_3, with saturation determined by high pressure, low temperatures, and biological activity. During oceanic water mixing, when deeper layers rise to the surface, conditions are created where CO_2 pressure in water exceeds atmospheric levels, leading to carbonic acid decomposition:

$$Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$$

Thus, the concentration of bicarbonate ions decreases sharply. The cyclical process of atmospheric CO_2 absorption and release of dissolved CO_2 is critical to maintaining this balance.

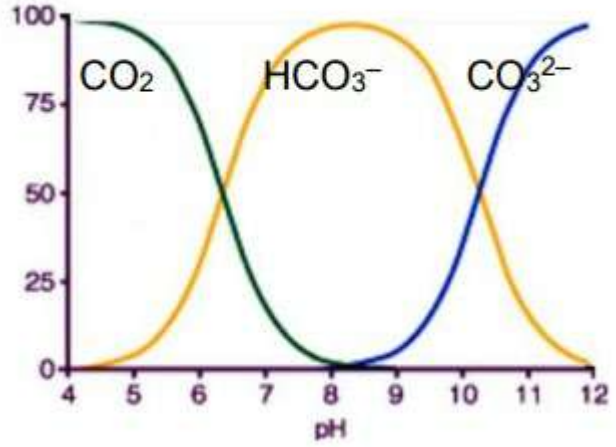

Fig. 1. Carbonic acid forms depending on pH

Carbon Cycling in Soil and Water

The chemical transformations of CO_2 in the "atmosphere-hydrosphere-lithosphere" system are influenced by the pedosphere, particularly the action of surface, soil, and groundwater on minerals and rocks. These processes are pH-dependent and vary based on the oxidation-reduction potential of the water. The acidity of water, linked to CO_2, HCO_3^-, and CO_3^{2-} concentrations, determines the form of carbon present (free carbon dioxide at pH < 8.4, bicarbonate ions at pH > 4.3, and carbonate ions at pH > 8.4).

$$CO_2 \rightleftharpoons HCO_3^- \rightleftharpoons CO_3^{2-}$$

Geochemical Processes

In the lithosphere, rainwater containing up to 10% CO_2 dissolves silicate and carbonate minerals, forming bicarbonate salts of alkali and alkaline earth metals. These waters penetrate deeper into the Earth's crust, forming groundwater rich in bicarbonate ions, which in turn dissolve calcite, chloride, and sulfate rocks. The CO_2 release occurs through carbonate decomposition at the surface, driven by sudden pressure drops, as described by the following reaction:

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

Carbon dioxide can also be released from Earth's depths during magmatic gas emissions or as a result of human activities such as fuel combustion and waste burning.

Biogenic Carbon Transformation

A unique factor influencing CO_2 transformations across Earth's spheres is biogenic accumulation and release of CO_2 through respiration. Biogenic sources, including microorganisms, phytoplankton, plants, and animals, play a critical role in capturing CO_2 through photosynthesis, chemosynthesis, and mineralization, while respiration and fermentation release CO_2 into the environment.

Conclusion

The chemical pathways of the carbon cycle are complex and multifaceted, involving interactions between the atmosphere, hydrosphere, lithosphere, and biosphere. Natural processes and human activities continuously influence the balance of CO_2 in Earth's ecosystems, with significant implications for global climate regulation and environmental sustainability.

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PHOSPHORYLATION OF SUBSTITUTED IMIDAZOLES

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Phosphorus-organic compounds in which a phosphorus atom is directly bonded to the imidazole nucleus represent a promising class of heterocyclic compounds with a wide range of biological activities. These compounds have potential applications in the development of new pharmaceuticals, including antitumor, antiviral agents, and treatments for type II diabetes. In addition, phosphorus-substituted imidazoles are commercially available phosphine ligands used in metal complex catalysts for C-C coupling reactions, aldehyde hydrogenation, and terminal alkyne hydration. These compounds are also used as intermediates in the synthesis of metabolic regulators and pesticides, as ionic liquids, and for the formation of complexes that model the functions of metalloenzymes . Thus, the study of phosphorylation reactions of substituted imidazoles is highly relevant today.

This research focuses on the electrophilic phosphorylation of 1,2-disubstituted imidazoles, conducted at the Department of Phosphorus Organic Compounds at the Institute of Organic Chemistry of the National Academy of Sciences of Ukraine. The department has a longstanding interest in the phosphorylation reactions of various heterocycles, discovering that 1-alkylimidazoles (and benzimidazoles) are phosphorylated by trivalent phosphorus halides to form 2-phosphorylated imidazoles (and benzimidazoles). Similar to the acylation of imidazoles , phosphorylation follows a ylide mechanism . This has led to the synthesis of a wide range of 2-phosphorylated imidazoles and an exploration of their properties, primarily focusing on the sensitivity of these phosphorus-containing

compounds to alkylating agents. Specifically, the direction of alkylation (on the cyclic nitrogen or phosphorus atom) depends on the hardness or softness of the alkylating agent: hard alkylating agents (e.g., Meerwein's salt) react at the nitrogen, while soft agents (e.g., MeI) react at the trivalent phosphorus .

Given the extensive literature on electrophilic substitution reactions in imidazoles , we decided to focus only on reactions that occur at the 4 and 5 positions of the imidazole ring, i.e., classical electrophilic substitution reactions. To determine whether electrophiles such as P(III) halides are capable of undergoing classical electrophilic substitution in imidazole at position 5, we needed to select and synthesize appropriate 1,2-disubstituted imidazoles. Additionally, the substituent at position 2 of the imidazole had to be non-reactive with P(III) halides, which excluded a large number of accessible 2-methyl and 2-methyl-substituted imidazoles. It was also essential to study the impact of the electronic properties of the substituent at position 2 on the phosphorylation reaction rate. The starting materials for phosphorylation reactions had to be commercially and synthetically accessible.

The starting compounds used in phosphorylation reactions were 1-methyl-2-thiomethyl-imidazole, obtained by alkylating the commercially available 1-methyl-2-mercaptoimidazole; 1-methyl-2-phenyl-imidazole, produced by alkylating 2-phenylimidazole; and 1-methyl-2-dimethylamino-imidazole, synthesized through multi-stage cyclization but with a good yield. The phosphorylating agents employed were traditional P(III) halides: phosphorus trihalides (PCl3, PBr3) and diphenylhalogenophosphines (Ph2PCl, Ph2PBr).

The study demonstrated the feasibility of direct phosphorylation of 1,2-disubstituted imidazoles at the 5-position of the heterocycle. The reaction of

such imidazoles with diphenylhalogenophosphines was investigated, and it was found that the electronic properties of the substituent at position 2 significantly affect the reaction rate. A series of 5-phosphorylated imidazole derivatives containing pentavalent phosphorus atoms was synthesized. These derivatives were shown to react with alkylating agents to form imidazolium salts. The spectral characteristics of the phosphorylated imidazoles were studied, and experiments using the nuclear Overhauser effect confirmed that phosphorylation occurred at the 5-position of the imidazole ring.

Conclusion

This research advances our understanding of the phosphorylation of 1,2-disubstituted imidazoles by traditional phosphorus halides. The study highlights the influence of electronic factors on reaction rates and confirms the regioselectivity of electrophilic substitution at position 5 of the imidazole ring. The results contribute to the development of novel phosphorylated heterocycles with potential applications in pharmaceuticals, catalysis, and materials science. Further investigation into the reactivity of these compounds with a broader range of electrophiles and alkylating agents could lead to the discovery of new functional materials and bioactive molecules.

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Social Sciences

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SUSTAINABILITY AND GREEN CAMPUS: A CASE STUDY OF UNIVERSITAS GADJAH MADA'S WASTE MANAGEMENT SYSTEM

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Green engineering and green architecture are integral components of the sustainability framework, focusing on minimizing environmental impact, optimizing resource use, and promoting human well-being. The primary goal is to balance economic feasibility with environmental stewardship, while addressing potential risks to keep them at a minimum. In the context of higher education, the concept of a "green campus" serves as a practical model for achieving sustainability goals. This model emphasizes reducing ecological footprints and integrating sustainable practices in campus infrastructure, operations, and policies.

This paper explores the role of waste management in green campus sustainability, particularly at Universitas Gadjah Mada (UGM), through the lens of Green Engineering principles and the UI GreenMetric research method. By analyzing UGM's efforts in waste management, we aim to illustrate how green engineering can be applied to real-world sustainability challenges, particularly in the academic sector.

Green Campus Sustainability Framework

Green campuses are developed based on principles of sustainability that integrate environmental, economic, and social dimensions. Among the different evaluation methods for campus sustainability, the UI GreenMetric World University Ranking stands out. This research method assesses the sustainability of campuses globally through six key criteria: Setting and Infrastructure, Energy and Climate Change, Waste Management, Water, Transportation, and Education and Research. Each criterion has specific

weights, with waste management being one of the most critical, accounting for 18% of the total score.

The importance of waste management in the context of a green campus is undeniable. Efficient waste management not only reduces environmental harm but also promotes resource efficiency, minimizes pollution, and fosters a culture of sustainability within the campus community. Universities, as knowledge hubs, have a significant role in setting an example for future leaders in sustainability and environmental stewardship. Therefore, implementing effective waste management practices in universities is crucial for achieving overall campus sustainability.

Green Engineering Principles

Green engineering is a holistic approach that seeks to design systems and processes that are sustainable, resource-efficient, and environmentally friendly. It is guided by twelve fundamental principles that align closely with sustainability goals. These principles address everything from material selection to energy efficiency and environmental impact reduction, providing a comprehensive framework for implementing sustainability practices in various sectors, including waste management.

At Universitas Gadjah Mada, the principles of green engineering are being applied extensively to achieve sustainability, particularly in the area of waste management. These principles ensure that the campus's waste management system is not only effective in reducing waste but also minimizes environmental impact and optimizes the use of resources.

The implementation of green engineering principles at UGM has led to the development of a comprehensive waste management system aimed at reducing waste generation, enhancing recycling, and minimizing the environmental impact of waste disposal. The university has adopted a

systematic approach, focusing on waste reduction at the source, waste segregation, and creating a circular economy model for waste recycling. Several initiatives have been introduced to make the campus's waste management process more sustainable, including:

Waste Segregation and Collection: UGM promotes the segregation of waste at the source, with separate bins for organic, inorganic, and hazardous materials. This practice is essential for reducing contamination in recyclable materials and ensuring that organic waste is processed into compost or biogas.

Recycling and Reuse: The university has set up dedicated recycling programs that focus on the reuse of paper, plastics, and metals. These programs not only reduce waste but also conserve natural resources by reintroducing used materials into the production cycle.

Composting: Organic waste generated on campus, particularly from food scraps and garden waste, is composted to create nutrient-rich soil for use in the university’s landscaping. This practice supports the university's goal of reducing its carbon footprint and minimizing landfill contributions.

Awareness and Education: UGM's waste management program emphasizes educating students and staff about the importance of sustainability and waste reduction. Workshops, seminars, and campaigns are regularly held to raise awareness and encourage active participation in waste reduction efforts.

Partnerships for Sustainable Waste Disposal: The university works closely with local waste management companies and governmental agencies to ensure that waste is processed in an environmentally responsible manner. This partnership ensures that UGM adheres to local regulations and uses sustainable technologies for waste disposal.

Assessment and Ranking of UGM's Green Campus Sustainability

Using the UI GreenMetric method, UGM's sustainability performance can be evaluated across various criteria. As mentioned, waste management plays a pivotal role in the assessment process, and the university's waste management system is critical to its sustainability ranking.

UGM has demonstrated significant commitment to achieving sustainability through effective waste management strategies. These efforts have contributed to its success in maintaining a competitive position in the global green campus rankings. The university's comprehensive approach to waste management, including waste segregation, recycling, and composting, aligns well with the UI GreenMetric criteria, and its dedication to reducing environmental impact has strengthened its sustainability credentials.

Challenges and Opportunities in Waste Management

While UGM's waste management system is advanced, there are still challenges to be addressed. One of the primary challenges is ensuring continuous participation and commitment from all members of the university community. Effective waste management requires collaboration between students, faculty, and staff, and a shift in mindset toward a more sustainable lifestyle. Moreover, the university must continue to explore innovative technologies and methods to improve waste processing, such as anaerobic digestion for organic waste or the adoption of zero-waste principles.

Another challenge lies in the management of e-waste, which is increasingly becoming a major concern in university campuses worldwide. As digital devices become more integral to academic and administrative functions, the disposal of electronic waste presents both environmental and

health risks. To address this, UGM must develop specialized programs for the recycling and safe disposal of e-waste.

Despite these challenges, there are significant opportunities for UGM to strengthen its waste management system further. By investing in more efficient waste processing technologies and enhancing public-private partnerships, the university can reduce waste to landfill, lower greenhouse gas emissions, and continue to set a global example in green campus sustainability.

In conclusion, waste management is a fundamental aspect of achieving sustainability in a green campus. The integration of green engineering principles at Universitas Gadjah Mada has enabled the university to develop an efficient and sustainable waste management system. Through waste segregation, recycling, composting, and educational initiatives, UGM is making significant strides in reducing its environmental impact. The application of the UI GreenMetric method to assess the sustainability of green campuses, with a particular focus on waste management, demonstrates the university's commitment to sustainability and environmental stewardship. However, challenges remain, particularly in the management of e-waste, and further innovation is needed to ensure the long-term success of the green campus program.

By continuing to develop and implement sustainable waste management practices, Universitas Gadjah Mada can serve as a model for other universities around the world, contributing to the global effort to achieve sustainability and environmental conservation.

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WATER DEMAND ANALYSIS IN KABUPATEN KULON PROGO IN THE CONTEXT OF NEW YOGYAKARTA INTERNATIONAL AIRPORT DEVELOPMENT

Intan Supraba, Universitas Gadjah Mada, Indonesia

Kabupaten Kulon Progo, a region in Yogyakarta Special Region (DIY), is experiencing rapid development due to the establishment of the New Yogyakarta International Airport (NYIA). As the area evolves into an aerotropolis, the demand for water is expected to rise, leading to potential water supply limitations. This study aims to quantify the water demand in Kabupaten Kulon Progo across various sectors, including domestic, non-domestic, irrigation, industrial, livestock, and fisheries. Accurate water demand projections are essential for sustainable resource management in light of the region's ongoing urbanization and economic development.

Methodology

This research employs a descriptive approach, utilizing secondary data from the Badan Pusat Statistik Kabupaten Kulon Progo (Central Bureau of Statistics). The analysis follows the guidelines provided by SNI 6728-1-2015 for calculating water demand across different sectors. The calculated water

demand includes domestic and non-domestic use, irrigation, industrial needs, livestock farming, and fisheries. The study primarily focuses on three major irrigation areas in the region: Kalibawang, Sapon, and Pengasih.

Results

The findings reveal that the highest water demand comes from irrigation needs, reflecting the agricultural focus of the region. The average annual water demand for the three main irrigation districts is as follows:

- Kalibawang Irrigation Area: 1.754 m^3/s
- Sapon Irrigation Area: 1.34 m^3/s
- Pengasih Irrigation Area: 1.366 m^3/s

These values indicate that irrigation consumes the most significant portion of water resources in Kabupaten Kulon Progo. Domestic water demand, essential for residential use, is calculated at 0.6157 m^3/s, while non-domestic water demand, which includes public facilities, is 0.1847 m^3/s. Other sectors show the following water demands:

- Livestock farming: 0.0603 m^3/s
- Industrial needs: 0.0061 m^3/s
- Fisheries: 0.000000040 m^3/s

The water demand in Kabupaten Kulon Progo demonstrates the region's reliance on agricultural irrigation, which accounts for the largest portion of water usage. The rapid development in the aerotropolis region surrounding NYIA has increased the strain on water resources, particularly in the non-agricultural sectors, where industrial and domestic demands are rising. Domestic water consumption is still relatively low compared to irrigation needs, but future urban growth in the region is expected to increase domestic and industrial water demand significantly.

The application of SNI 6728-1-2015 as a standard for water demand calculations ensures that the estimates are consistent with national regulations, providing a reliable basis for water resource planning in the region. These findings will be crucial for policymakers and urban planners in ensuring a sustainable water supply as the region continues to develop.

Conclusion

This study highlights the importance of addressing water demand in Kabupaten Kulon Progo as it undergoes rapid urban and economic transformation due to the development of the aerotropolis surrounding NYIA. The water demand for irrigation remains the most significant, but future projections indicate an increasing need for domestic and industrial water supply. Sustainable water management strategies will be essential to support both agricultural activities and the growing urban population. Further research and detailed water supply planning will be necessary to ensure that the region can meet its water needs without compromising long-term sustainability.

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ENHANCING IMAGINATIVE THINKING IN PHYSICS EDUCATION: THE ROLE OF MIND MAPS, THOUGHT EXPERIMENTS, AND CREATIVE ASSESSMENT

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Imaginative thinking is essential for understanding the abstract and complex nature of physics. This paper explores how mind maps and thought experiments can foster the development of imaginative thinking in students and improve their understanding of physics concepts. It also introduces methods for assessing imaginative thinking, such as creativity tests, including the Torrance Tests of Creative Thinking (TTCT). Additionally, the article delves into how imaginative thinking positively influences physics learning outcomes and provides practical approaches for educators to integrate these methods into the physics curriculum. The analysis shows that students with higher levels of imaginative thinking achieve better performance in physics, particularly in problem-solving and conceptual understanding.

Keywords: imaginative thinking, mind maps, thought experiments, physics education, creative assessment, Torrance Tests of Creative Thinking.

1. Introduction

Imaginative thinking has been recognized as a key factor in scientific creativity and innovation, particularly in fields like physics that require the mental visualization of abstract concepts. The ability to manipulate mental images and create visual representations of phenomena that cannot be directly observed plays a crucial role in the learning process. In physics, students often struggle with concepts that are too abstract or distant from

everyday experiences, such as electromagnetic waves, quantum mechanics, and relativistic effects. This paper argues that the development of imaginative thinking can bridge the gap between theoretical knowledge and practical understanding, enabling students to internalize complex ideas more effectively.

In recent years, the use of cognitive tools such as mind maps and thought experiments has gained attention for their potential to enhance imaginative thinking in education. These methods allow students to visualize and organize information more creatively, promoting a deeper understanding of concepts and their relationships. Thought experiments, in particular, encourage students to engage in mental simulations of physical scenarios, offering a way to explore abstract phenomena without the need for real-world experimentation.

This paper aims to explore how these methods contribute to imaginative thinking in physics education, suggest ways to measure this thinking using appropriate tests, and examine how the development of imaginative thinking impacts students' performance in physics.

2. The Importance of Imaginative Thinking in Physics

Physics is a discipline that often demands students to think beyond the tangible world and engage with abstract concepts. From the behavior of subatomic particles in quantum mechanics to the nature of electromagnetic fields, the study of physics requires a level of conceptualization that goes beyond mere rote learning. Traditional teaching methods, which focus primarily on equations and problem-solving techniques, do not always address the cognitive challenges students face when trying to visualize complex ideas.

2.1 Cognitive Theories Supporting Imaginative Thinking in Physics

Cognitive psychology suggests that imaginative thinking is critical for deep learning, particularly when students are required to understand abstract scientific phenomena. According to dual-coding theory, developed by Allan Paivio, human cognition involves two distinct but interconnected systems: a verbal system for language and a visual system for imagery. In physics education, both systems need to be activated to effectively comprehend abstract concepts.

For example, the study of electromagnetic waves involves understanding both the mathematical representation of wave functions and the visual-spatial properties of waves as they propagate through space. The simultaneous use of both verbal and visual information enhances comprehension by enabling students to create mental models of physical phenomena. This is where imaginative thinking becomes vital: students must be able to form mental representations of phenomena they cannot directly observe.

2.2 How Imaginative Thinking Enhances Physics Learning

Imaginative thinking allows students to mentally simulate physical processes, which improves their understanding of the laws that govern these processes. For instance, in classical mechanics, students can use imaginative thinking to visualize how forces interact to cause motion, or how objects behave under the influence of gravity. This ability to mentally manipulate physical phenomena enables students to grasp not only how physical systems work but also why they work the way they do.

In quantum mechanics, imaginative thinking becomes even more important. Students must develop an intuitive sense of wave-particle duality, superposition, and quantum entanglement—concepts that have no direct analog in everyday experience. By fostering imaginative thinking,

educators can help students develop the mental flexibility needed to grasp these challenging ideas.

3. Tools to Enhance Imaginative Thinking in Physics Education

3.1 Mind Maps

Mind maps are an excellent tool for organizing information in a way that reflects the hierarchical and relational structure of complex topics. In physics, where multiple concepts often interrelate, mind maps help students visualize these connections and understand how different pieces of information fit together. For example, when studying electromagnetic waves, a mind map can illustrate how wave properties like frequency, wavelength, and amplitude relate to one another, as well as how these properties influence phenomena such as reflection, refraction, and diffraction.

Mind maps are not only useful for organizing information but also for stimulating imaginative thinking. By encouraging students to create their own mind maps, teachers can foster an active learning environment where students engage with the material more creatively. Instead of passively absorbing information, students actively construct their understanding of the topic, which promotes deeper cognitive processing and better retention of the material.

3.2 Thought Experiments

Thought experiments have long been used by physicists to explore the implications of theoretical ideas. Albert Einstein famously used thought experiments to develop his theory of relativity, imagining himself riding on a beam of light to conceptualize the behavior of space and time at relativistic speeds. By engaging in similar thought experiments, students can develop

their imaginative thinking and enhance their understanding of complex physical concepts.

For instance, in a classroom setting, students might be asked to imagine a scenario in which they are inside a spaceship traveling at nearly the speed of light. What would they observe if they looked at a clock on Earth? Such thought experiments can help students develop a more intuitive understanding of time dilation and other relativistic effects, concepts that are difficult to grasp through equations alone.

4. Measuring Imaginative Thinking in Physics Education

While imaginative thinking is often considered a subjective cognitive process, there are ways to measure and evaluate it objectively in educational settings. One of the most widely used tools for assessing creative thinking is the Torrance Tests of Creative Thinking (TTCT), which can be adapted to assess imaginative thinking in physics.

4.1 Torrance Tests of Creative Thinking (TTCT)

The TTCT measures various aspects of creativity, including fluency, originality, and elaboration. These tests can be adapted to measure imaginative thinking in physics by designing tasks that require students to generate creative solutions to physics-related problems.

For example, in a TTCT-style task for physics, students might be asked to think of as many ways as possible to use the principles of electromagnetism to solve everyday problems. The number of solutions they generate (fluency), the uniqueness of their ideas (originality), and the level of detail in their explanations (elaboration) can all be measured to assess their level of imaginative thinking.

4.2 Customized Physics Creativity Test

In addition to the TTCT, customized creativity tests can be designed to measure imaginative thinking specifically in physics. For example:

Test 1: Visualizing Gravitational Forces

Students are presented with a hypothetical scenario in which they must imagine the gravitational forces acting on an object at different points in space. They are then asked to draw the force vectors and explain how these forces influence the object's motion.

Test 2: Imagining Quantum States

Students are asked to imagine an electron in a quantum state and describe how its position and momentum might change according to the principles of quantum mechanics. This task encourages students to engage with abstract concepts and visualize phenomena that cannot be directly observed.

4.3 Diagrams and Drawings for Evaluation

One effective way to measure imaginative thinking is through the use of diagrams and drawings. Students can be asked to draw their visualizations of physical phenomena, such as the flow of electric current in a circuit or the motion of particles in a gas. By evaluating the accuracy and creativity of these drawings, educators can assess the students' ability to think imaginatively about the physical world.

5. How Imaginative Thinking Affects Physics Learning

5.1 Problem-Solving Skills

Imaginative thinking has a direct impact on students' problem-solving abilities in physics. When faced with a complex problem, students with well-developed imaginative thinking skills are better able to visualize the relationships between different variables and develop creative solutions. For example, in mechanics, students who can mentally simulate the motion of

objects under the influence of different forces are better equipped to solve problems related to motion, acceleration, and force.

5.2 Conceptual Understanding

Beyond problem-solving, imaginative thinking also enhances students' conceptual understanding of physics. By engaging in thought experiments and visualizing physical phenomena, students can develop a deeper understanding of the underlying principles that govern the behavior of the physical world. For instance, when studying thermodynamics, students who can visualize the microscopic motion of particles in a gas are more likely to grasp the laws of energy transfer and entropy.

5.3 Long-Term Retention

Research has shown that students who engage in imaginative thinking are more likely to retain the information they learn over the long term. By creating mental models and visual representations of physical phenomena, students encode the information more deeply, which leads to better retention and recall. This is particularly important in physics, where concepts often build on one another and require cumulative knowledge.

6. Practical Applications for Educators

Educators can foster imaginative thinking in their physics classrooms by incorporating mind maps, thought experiments, and creativity assessments into their teaching methods. For example, teachers can assign students to create mind maps at the beginning of each unit to help them organize the key concepts and relationships. Thought experiments can be introduced during lectures to encourage students to engage with the material more actively.

Assessment strategies should also be adapted to measure students' imaginative thinking. In addition to traditional problem-solving questions,

exams can include tasks that require students to draw diagrams, explain hypothetical scenarios, and generate creative solutions to real-world problems.

7. Conclusion

Imaginative thinking is a crucial skill for success in physics education. By developing students' ability to visualize and manipulate abstract concepts, educators can help them achieve a deeper understanding of physics and improve their problem-solving abilities. Tools such as mind maps, thought experiments, and creativity assessments like the Torrance Tests of Creative Thinking can be used to foster and measure imaginative thinking in the classroom. Ultimately, students who develop strong imaginative thinking skills are better equipped to tackle the challenges of modern physics and succeed in their academic pursuits.

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QUANTUM ALGORITHMS FOR NATURAL LANGUAGE PROCESSING: A COMPOSITIONAL APPROACH

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Quantum computing and artificial intelligence (AI) have found a fruitful intersection in natural language processing (NLP). In this work, we explore a quantum adaptation of the recently proposed DisCoCirc framework for NLP, named QDisCoCirc. This model leverages the principles of compositionality to offer interpretable AI, where the behavior of the whole can be derived from its parts and their interactions. We derive quantum algorithms for fault-tolerant quantum computers to address the task of question-answering within QDisCoCirc, showing that the problem is BQP-hard. Under classical assumptions, implementing this model would require super-polynomial resources, highlighting the potential of practical quantum processors for significant advancements.

Introduction

Natural language processing is a key area where quantum computing could provide exponential speedups over classical algorithms. Specifically, the intersection between quantum computing and AI holds promise in improving tasks such as text similarity, question-answering, and word embeddings. We propose QDisCoCirc, a quantum adaptation of the DisCoCirc framework, as a compositional quantum natural language processing (QNLP) model. The model focuses on rendering AI interpretable by leveraging quantum circuits, where each part of the text corresponds to a specific quantum gate, and the structure of the sentence determines how these gates are composed.

Compositional Model and Word Embeddings

The main challenge in NLP is representing the meaning of words and sentences in a way that both captures the linguistic structure and allows for efficient computation. Word embeddings are commonly used in classical NLP, but we propose a quantum equivalent by encoding word embeddings into parameterized quantum circuits. The quantum state associated with a word is represented as:

$$|w\rangle = U_w(\theta)|0\rangle,$$

where $U_w(\theta)$ is a unitary operator parameterized by θ, and $|0\rangle$ is the initial quantum state.

The compositionality of the model means that the quantum circuits for sentences are constructed by combining the quantum circuits of individual words. If a sentence has the form "word1 word2," the corresponding circuit would be:

$$U_{sentence} = U_{word1} \otimes U_{word2}.$$

This operation respects the grammatical structure of the sentence, ensuring that the meaning of the sentence as a whole is derived from the quantum states of the individual words.

Quantum Algorithms for NLP

For the primitive task of text similarity, we derive a quantum algorithm for question-answering within QDisCoCirc. The problem can be reduced to finding the closest vector in a high-dimensional space, which is a known NP-hard problem in classical computing. Quantum computers, however, can solve this problem more efficiently using a quantum algorithm for the closest vector problem (CVP). The algorithm works by preparing superpositions over possible word embeddings and performing amplitude amplification, similar to Grover's search algorithm.

The Grover-like speedup in the fault-tolerant regime for the QDisCoCirc model provides a quadratic speedup over any classical algorithm. In certain conditions, the time complexity of the quantum algorithm is reduced to:

$$O(\sqrt{N}),$$

where N is the number of possible word embeddings or text states.

Complexity of Question-Answering

We show that the task of question-answering in the QDisCoCirc framework is BQP-hard, meaning it is as difficult as the hardest problems solvable in bounded-error quantum polynomial time (BQP). Although we do not claim this complexity result for other NLP models, this demonstrates that quantum algorithms can significantly reduce the computational resources required for solving certain NLP tasks.

Evaluation on Near-Term Quantum Devices

In the near term, quantum devices are noisy and lack full fault tolerance, which limits their computational capabilities. Nevertheless, we outline an approach for implementing QDisCoCirc on noisy intermediate-scale quantum (NISQ) devices. The idea is to use variational quantum algorithms where the parameters of the quantum circuits are optimized using classical techniques. This hybrid quantum-classical approach allows us to test the model's effectiveness in practice, even on today's limited quantum hardware.

A recent implementation of this model on quantum hardware has shown promising results, though more work is needed to refine the methods and improve the hardware's noise resilience.

Conclusion and Future Work

In this paper, we introduced QDisCoCirc, a quantum model for compositional natural language processing. The quantum adaptation allows for the efficient handling of tasks like text similarity and question-answering, providing significant speedups over classical algorithms. In future work, we aim to empirically verify the theoretical speedups provided by quantum algorithms for the closest vector problem, and further explore the model's applications on larger quantum processors.

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CARBON COMPOSITE MATERIALS AS IMPLANTS FOR ORTHOPEDICS AND TRAUMATOLOGY

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In traumatology and orthopedics, the understanding of osteosynthesis combines the study of the physical and physiological properties of the human musculoskeletal system with the configuration and material science of implants. The main directions of osteosynthesis development are minimizing surgical interventions, achieving minimal invasiveness, reducing blood loss, and shortening the duration of operations. The treatment of bone fractures is a critical medical issue with significant social implications. The quality and speed of bone fracture healing depend on the location of the injury, the stability of fixation, the size of the interfragmentary gap, the overall condition of the body, and other factors. The use of carbon-carbon composite materials for osteosynthesis is especially promising for addressing this issue. The choice of carbon as a material for medical products is based on its unique natural properties, such as high biocompatibility.

Currently, the optimal treatment for unstable metaphyseal and metadiaphyseal fractures of long bones remains a subject of debate. The close proximity of such fractures to the joint makes their surgical treatment more challenging compared to fractures located in the diaphyseal zone. Various methods have been proposed for treating these injuries: external osteosynthesis, plate fixation, intramedullary osteosynthesis, and conservative methods. However, each treatment option has its advantages, disadvantages, and specific indications. Bone fixation with plates and screws is a common and effective option for osteosynthesis of metaphyseal and

metadiaphyseal fractures. There are several main types of plates (support, compression, bridge-like) used depending on the anatomical area and the size of the bone. The drawbacks of open reduction and bone fixation with a plate include significant soft tissue dissection, which can lead to infections and other complications.

In the 1960s, the use of carbon implants experienced a kind of boom. Numerous publications were devoted to the use of carbon materials in medicine, particularly in orthopedics and traumatology. The experimental and clinical use of various types of carbon-containing implants was studied. The first publications about the successful use of carbon implants in clinical practice abroad appeared in the 1980s-1990s, while in Ukraine, research continued at the beginning of the 21st century. The practical use of carbon implants began primarily in dental practice. This was because small implants used in dentistry were easier to adapt to the human body and did not cause adverse reactions. M. Hossain justified the use of carbon-based endoprostheses in the treatment of bone diseases of the temporomandibular joint in children and adolescents. Another reason for the interest of traumatology and orthopedics in carbon implants is malignant bone neoplasms. In recent years, the arsenal of biosynthetic replacement materials has significantly expanded. Various biomaterials are used during reconstructive and restorative operations on the skeleton, including calcium-phosphate ceramics, bioglass, bone cement, and biodegradable polymers such as polylactide and polyglycolide. The use of nanotechnology has enabled the creation of carbon-based nanotubes, which have been successfully used to stimulate bone regeneration in combination with pharmaceuticals and bioactive macromolecules that form the bone matrix.

The authors of the work [4] emphasize that metal orthopedic materials share a common history of use with the aerospace industry, which makes them only partially effective in the biomedical field. However, their suitability for bone replacement and regenerative therapy remains undisputed due to their excellent mechanical properties, even though they are not fully biocompatible. As previously noted, one of the debatable issues in the application of composite materials in osteosynthesis is their ability to withstand mechanical loads. Despite the fact that the ultimate stress levels that carbon-composite materials can withstand at room temperature are not significantly lower than those of metals used in osteosynthesis [5], one challenge is their ability to endure significant contact loads and stresses at the constructive stress concentrators and fastening nodes.

Research results indicate that carbon-carbon material is bioinert, as confirmed by the absence of cellular reactions around carbon fragments. The mechanical properties of modern carbon composites can be engineered to match those of living bone. The residual porosity of the carbon composite material allows for the impregnation of implants with various substances, such as antibiotics, antiseptics for antimicrobial activity, or calcium phosphate-based surfactants to promote the osteoinductive properties of the implant.

Research on the use of carbon implants in orthopedic practice is currently most actively conducted in the USA, France, and Japan. In this case, preference is given to carbon implants impregnated with epoxy or polyetheretherketone (PEEK) (REEC). However, to date, there is no theoretically and experimentally validated technology for osteosynthesis of metaphyseal and metadiaphyseal fractures of long bones using carbon implants that provide reliable, long-term fixation of bone fragments. One

promising application of such materials is for fractures of the proximal part of the shoulder.

The proximal part of the humerus is involved in 32-65% of upper extremity injuries [11]. Damage to the proximal humerus is often accompanied by persistent dysfunction and long-term disability [11]. Treating patients with this pathology is challenging, as the majority are elderly. According to various authors, over 80% of individuals with proximal humerus fractures are over 50 years old, with women making up 60-70% of this group, due to concurrent systemic osteopenia or osteoporosis [6,7,8,11]. In elderly patients, multicomminuted fractures are common, where the surgical neck of the humerus is fragmented and no longer exists as an anatomical structure [10,11,16]. A quarter of patients with these fractures also have damage to the rotator cuff of the shoulder [13,14,18]. It has been noted that even with minimal displacement of the greater tubercle, 25% of cases result in disruption of the rotator cuff of the shoulder (RMP) [9,11,12,16]. The failure of the RMP occurs due to the detachment of its attachment point on the humerus along with the greater tubercle fragment [9,13].

In recent years, most authors agree on the efficacy of conservative treatment for stable fractures and surgical intervention for unstable injuries. Many researchers highlight significant challenges in achieving anatomical repositioning of fractures in the proximal humerus [6,7,10,11]. This is particularly true for elderly patients with osteoporosis, whose fractures tend to involve many fragments [14,16]. A decrease in bone mineral density leads to instability in metal structures [16]. Preserving blood circulation in the humeral head is critical, as it is supplied by the arcuate artery (arteria arcuata), a branch of the anterior circumflex artery (a. circumflexa humeri

anterior), which originates inside the medial edge of the intertubercular groove at the level of the surgical neck of the humerus [15]. Typical complications following surgery include improper fracture union, loss of fixation stability, damage to articular surfaces, avascular necrosis of the humeral head, and neurovascular complications [17,18].

Conclusions

Based on the literature and our own research, we have established that various forms of carbon are non-toxic and safe. They offer a sufficient reserve of mechanical strength, making them suitable for the manufacture of fasteners for osteosynthesis applications.

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PROBLEMS OF FORMING THE INNOVATIVE BUILDING MARKET MATERIALS IN UKRAINE

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The main feature of the modern economy is the transition to a new, innovative phase of development and the construction of an innovative economy. However, the pace at which innovations that optimize construction processes are introduced leaves much to be desired. The main reasons preventing the spread of new technologies are identified by experts as the conservatism of consumers, the lack of a regulatory framework,

lobbying by producers of traditional materials, and a lack of investment.

Currently, there is a global trend towards the formation of an economy based on knowledge, which is primarily oriented towards social innovation in various fields, including the creation and use of new materials and environmentally friendly technologies.

On the one hand, the construction industry is conservative in terms of implementing and widely distributing innovative technologies. On the other hand, among the innovative industries in leading economic states, building materials are far from being a leader and occupy one of the last positions. Unfortunately, this trend persists. At the same time, the development and implementation of innovations in the field of building materials is one of the most actively developing areas of scientific and technical activity at present.

The formation of the innovative building materials market has been the subject of works by leading Ukrainian scientists. Despite numerous studies and developments, as well as efforts to identify issues in this area, there remains a need for further investigation.

Despite the development and use of innovations, the construction industry reacts slowly and reluctantly to them. This is primarily due to the long service life of buildings and structures, during which unforeseen shortcomings of the applied technology may arise. As a result, construction companies are cautious about adopting new materials or construction methods. Secondly, there is a high degree of responsibility on builders for the final product, which is explained by the risk of unfortunate consequences, including threats to people's lives, if inappropriate technologies are used or mistakes are made at the design stage.

In the modern market, there is increasing demand for innovative building materials that are no less ecological than natural materials, yet more durable and affordable. Examples include fibrous boards made of pressed wheat or hemp straw, glue for assembling prefabricated houses, composite reinforcement, 3D printing, and aerogels, among others.

When researching innovations in the field of building materials, special attention should be given to the sectoral characteristics of innovations and their target orientation. For the building materials field, the following types of innovations are possible:

Implementation of new solutions in planning and architectural matters regarding the appearance of the object under construction.

Use of modern construction materials, machines, and equipment that reduce construction time and costs.

Introduction of effective innovative construction technologies.

Improvement of the production technology of thermal insulation materials that are both low-cost and high-quality.

Application of new and high-quality construction and finishing materials.

Introduction of new organizational forms of work performance.

All of the above types of innovation are interrelated and dictate certain requirements for innovative activity in the building materials market.

Problems Preventing the Formation of the Innovative Building Materials Market Insufficient number of qualified workers in the production of innovative building materials.

In Fig. 1, we can see the percentage of the employed population in various industries in 2021. [4].

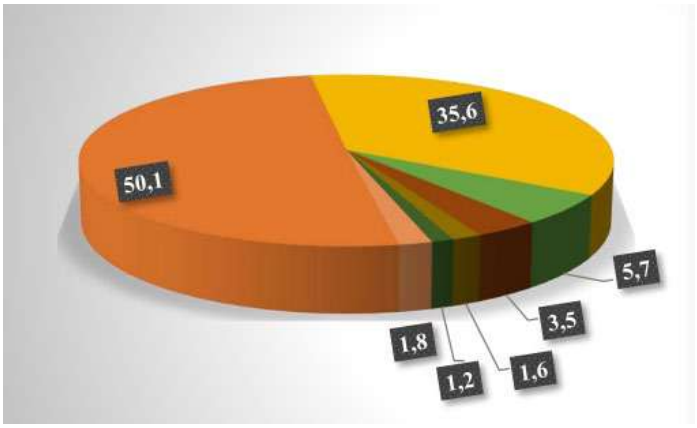

Fig. 1. Branch Structure of the Manufacturing Industry of Ukraine in 2021 (Percentage of Employed Population)

The share of employment in the field of construction material production is quite small, standing at only 5.7%. In this field, the majority of employees are men, and due to martial law and mobilization, there is a shortage of workers. It is predicted that, with the end of the war and the beginning of reconstruction in the country, the demand for construction materials will sharply increase. Thus, the issue of personnel shortages must be addressed today.

- ✓ Distrust of innovations by consumers.
- ✓ Lack of financial resources for innovative research.
- ✓ Dominance of small firms in the market, which lack sufficient resources to introduce innovations.
- ✓ Cyclical nature of the construction industry and peculiarities of climatic conditions.

Low degree of integration in the construction sector, which provokes resistance and dependence on traditional methods.

On the one hand, the construction industry is conservative regarding the implementation and wide distribution of innovative technologies. On the other hand, the market of innovative building materials in leading economic states is not in the forefront but rather one of the last, unfortunately. At the same time, the development and implementation of innovations in the field of building materials is one of the actively developing areas of scientific and technical activity.

Issues related to the formation of the innovative construction materials market are discussed in the works of leading Ukrainian scientists. Despite the significant amount of research and development in this area, the need for further study remains, as well as the identification of problems.

Despite the development and use of innovations, the construction industry reacts slowly and reluctantly to them. This is primarily due to the long term of operation of buildings and structures, during which unforeseen shortcomings of applied technology may appear. As a result, construction businesses are cautious when adopting new materials or methods. Secondly, there is a high level of responsibility for the final product, which is explained by the risk of unfortunate consequences, even to the point of threats to people's lives if inappropriate technologies are used or mistakes are made at the design stage.

In the modern market, there is an increasing demand for the development of innovative building materials that are no less ecological than natural ones but are more durable and affordable (e.g., fibrous boards made of pressed wheat or hemp straw, glues for prefabricated houses, composite reinforcement, 3D printing, aerogel, etc.).

When researching innovations in the field of building materials, the

primary focus should be on the distinctive sectoral features of innovations and their target orientation. In relation to building materials, the following types of innovations are possible [1]:

- ✓ Implementation of new solutions in planning and architectural matters, such as the appearance of the object under construction.
- ✓ Use of modern construction materials, machines, and equipment that allow for reduced construction timelines and lower specific costs.
- ✓ Implementation of effective innovative construction technologies.
- ✓ Improvement of the production technology of thermal insulation materials that are low-cost and high-quality.
- ✓ Application of new and high-quality construction and finishing materials.
- ✓ Application of new organizational forms of work performance.
- ✓ All the listed types of innovation are closely related and impose specific requirements on innovative activities in the building materials market.

Problems Preventing the Formation of the Innovative Building Materials Market:

Insufficient number of qualified workers in the production of innovative building materials. In Figure 1, we can see the percentage of the employed population in various industries in 2021 [4].

In the field of building materials production, the share of employed people is quite small, only 5.7%. In this field, the majority of the employees are men, and due to martial law and mobilization, there has been a shortage of workers. It is predicted that after the war ends and reconstruction begins,

the demand for construction materials will sharply increase, so the personnel shortage needs to be addressed today.

- ✓ Distrust of innovations on the part of buyers.
- ✓ Lack of financial resources for innovative research.
- ✓ Predominance of small firms in the market with insufficient resources to introduce innovations.
- ✓ Cyclical nature of construction and peculiarities of climatic conditions.
- ✓ Low degree of integration in the construction sector, leading to resistance.

Decrease in the level of foreign investment and a fall in the investment attractiveness index of the country as a whole in 2021-2022 [5]. However, economists foresee an increase in this indicator after the end of hostilities and the beginning of reconstruction in the country.

Unstable economic and political situation in Ukraine, which sometimes leads to a rise, then a sharp drop in indicators. For the sustainable innovative development of the construction products market, it is necessary for the construction industry to have a steady pace of construction.

Sharp rise in prices for all building materials. Main factors: loss of control over territories, destruction of enterprises, lack of raw materials, disruption of logistics chains, and reorientation to procurement from the European Union and Turkey.

- ✓ Absence of a unified system of approbation and certification of new building materials.
- ✓ Limited access to information about new materials and

insufficient established connections between research centers and construction enterprises.

- ✓ High tax burden on enterprises engaged in the market of innovative building materials.
- ✓ High level of inflation.
- ✓ Weak support for innovative activities from the state, etc.

Currently, experts highlight the lack of a developed functional information system as one of the most crucial problems in forming the innovative building materials market. Consequently, the innovation market remains opaque regarding information about the main participants, organizational and legal work conditions, and directions for direct and indirect state support for innovative activities in the field of building materials. The lack of information about developments and profitable projects being implemented leads to a decrease in investment activity, significantly reducing financing opportunities for innovative activities in building materials. On the other hand, developers with export-oriented technologies also lack information about foreign markets, regulatory frameworks, and industry development prospects, as well as potential investors.

In the conditions of globalization and increased international competition, priority tasks for the development of the innovative building materials market in Ukraine include ensuring a high level of innovative activity. The successful implementation of this task is possible only if science-intensive innovations are introduced systematically and consistently. The insufficient level of implementation of scientific developments in the field of building materials has led to a technological lag

from the developed countries of the world. This process results in a sharp decline in the competitiveness of the national economy, inhibition of technological development in the construction materials market, and a decrease in the qualification level of the workforce. These circumstances may lead to the disappearance of the material and technical base necessary for scientific research and the attraction of cheap, low-quality technologies from abroad.

An analysis of the latest official statistics indicates a deficit of financial resources that enterprises could direct toward realizing their innovative strategies. Under such conditions, it is advisable to expand the structure of financial support sources for construction organizations. The priority is to find new ways of financing innovation and investment activity.

Among the areas for implementing innovative technologies in the construction materials field are the following:

Strengthening the interaction of various economic entities in this field (construction enterprises, building materials production enterprises, project enterprises, research institutes, and higher educational institutions).

Creation of a single integrated information system containing all information about innovative research conducted in the industry and construction.

Search for new ideas and the actualization of existing developments.

Purchase of advanced foreign technologies and patents for the further organization of domestic production of building materials.

Training of workers and specialists in new technologies and skills for working with new mechanisms and building materials.

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MACHINE LEARNING: THEORY, TECHNIQUES, AND APPLICATIONS

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Machine Learning (ML) is one of the key fields of Artificial Intelligence (AI), focusing on practical applications of AI capabilities by creating algorithms that detect patterns when analyzing large datasets. These patterns are then utilized for self-learning systems, allowing machines to improve their performance over time. The fundamental goal of machine learning is not to solve a single task but to teach the machine how to perform other similar tasks effectively.

The purpose of machine learning is to predict outcomes based on input data. The more diverse the input data, the easier it is for the machine to detect patterns, thus leading to more accurate predictions. To teach a machine, three core components are required:

Data: A vast amount of data, often consisting of tens of thousands of examples, is essential for training the system. The specific type of data depends on the task the machine is designed to perform. For example, to understand user interests, social media likes and posts are needed; to detect spam, examples of spam emails are necessary; and for stock price predictions, historical price data is used. Data can be collected manually (time-consuming but reliable) or automatically (faster but riskier). Moreover, sometimes data is collected via tasks that humans unknowingly perform. For example, CAPTCHA tasks (e.g., identifying traffic signs in images) help teach AI systems to recognize patterns.

Features: These are characteristics or attributes that describe the items of interest. The machine needs to be aware of what specific features to focus on. For instance, to categorize items, features like price, quality, and material might be essential.

Algorithm: The algorithm defines how the machine solves a given problem. While the same problem can be solved using various methods, the choice of algorithm influences the speed and quality of the solution. There are several types of machine learning algorithms, each suited for different purposes.

Machine learning can be broadly categorized into four types:

Classical Learning (with and without a teacher)

Reinforcement Learning

Ensemble Methods

Neural Networks and Deep Learning

Classical Learning

Classical machine learning is divided into two main categories: supervised and unsupervised learning.

Supervised Learning: In this type, a "teacher" provides the machine with labeled data (i.e., data with known outcomes). The machine is trained using these labeled examples, learning to associate input data with specific outcomes. The primary objective is for the machine to learn to predict the correct output for new, unseen data. The methods used in supervised learning are further divided into two categories:

Classification: This is the task of assigning labels to input data. For example, categorizing emails as spam or not spam. It is akin to sorting toys into different boxes (e.g., robots in one box, tanks in another).

Regression: This method deals with predicting continuous values, such as price, demand, or time. It is ideal for problems where the outcome is a numerical value that depends on various input factors. Financial analysts and statisticians often use regression for forecasting, and it can even be found in tools like Excel.

Unsupervised Learning: Unlike supervised learning, unsupervised learning does not rely on labeled data. Instead, the machine is tasked with identifying patterns and structures within the data on its own. There are three main methods of unsupervised learning:

Clustering: The machine groups similar items together into clusters. The number of clusters can be pre-defined or determined by the machine. Clustering is useful when there are no known categories, and the system must find natural groupings within the data.

Dimensionality Reduction (Generalization): In this method, the machine reduces the complexity of the data by grouping features into broader categories. For example, instead of analyzing every individual feature of a document, the machine focuses on the overall theme or topic of the document to find similar ones.

Association Rule Learning: This technique is used to find relationships between variables in large datasets. For instance, it can identify items that are frequently bought together in online stores, suggesting related products to users.

Reinforcement Learning

Reinforcement learning is used in scenarios where the objective is not data analysis but survival in a dynamic environment. The environment could range from a video game, like Mario, to real-world applications, such as autonomous driving. In reinforcement learning, the machine learns by interacting with the environment and receiving feedback in the form of rewards or penalties. The aim is to minimize errors and improve performance over time. For example, Tesla's self-driving cars use reinforcement learning to avoid obstacles and optimize driving behavior.

Ensemble Methods

Ensemble methods combine multiple learning models to improve overall performance. The idea is simple: if individual models are weak, but

their mistakes can be corrected by others, the collective performance of the ensemble will be much stronger. There are three main ensemble methods:

Stacking: Different algorithms are trained independently, and their results are passed to a final "meta-model" that makes the ultimate decision. This method can be compared to a family making a collective decision, where the final decision is made by the "head of the family."

Bagging (Bootstrap Aggregating): The algorithm is trained multiple times on different random subsets of the data. The results are then averaged to obtain the final output. This technique helps reduce variance and avoid overfitting.

Boosting: In boosting, algorithms are trained sequentially. Each subsequent model focuses on the mistakes made by the previous one. This iterative process helps refine predictions and improve model accuracy.

Neural Networks and Deep Learning

A neural network consists of layers of interconnected neurons, where each neuron is responsible for processing a set of inputs and generating an output. The connections between neurons are weighted, and these weights control the strength of the signals between neurons. Neural networks are particularly powerful for solving complex problems like image recognition, natural language processing, and speech recognition.

Deep learning refers to neural networks with many layers (also known as deep neural networks). These networks are capable of learning hierarchical representations of data, which makes them highly effective for tasks like computer vision and autonomous driving. A key advantage of deep learning is its ability to automatically extract features from raw data,

eliminating the need for manual feature engineering.

Applications of Machine Learning

Machine learning has transformed numerous industries, from e-commerce to healthcare. One of its most widespread uses is in personalized recommendation systems, such as those used by Netflix, Spotify, and Amazon. These systems analyze user behavior and preferences to suggest products, movies, or songs that the user is likely to enjoy.

Other notable applications of machine learning include:

Image and Speech Recognition: Machine learning models can now identify objects in images and transcribe spoken language into text.

Medical Diagnosis: AI systems can analyze medical data, such as X-rays or MRI scans, to assist doctors in diagnosing diseases more accurately.

Spam Detection: Machine learning algorithms are commonly used to filter out unwanted emails and messages by identifying patterns typical of spam.

Financial Analysis and Trading: Machine learning is widely used for forecasting stock prices, assessing risks, and detecting fraudulent activities in the financial sector.

Conclusion

Machine learning is a rapidly growing field with vast potential across numerous domains. Its applications are reshaping industries and driving innovation in areas like healthcare, finance, and entertainment. The ability of machines to learn from data and improve over time is transforming the way we interact with technology, and as algorithms continue to evolve, their

impact on society will only increase. Machine learning, with its diverse methods and techniques, offers solutions to complex problems that were once considered beyond reach, marking the beginning of a new era in artificial intelligence.

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KEY ASPECTS OF AUDITING IN THE CONTEXT OF MODERN DIGITALIZATION

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Currently, we are witnessing a rapid increase in information flows, while the competitive environment of market relations demands ever-higher standards of quality, reliability, timeliness, and completeness of information for the conduct of all types of activities. The majority of enterprises today cannot carry out a single financial operation without an automated workplace. Automation and computerization are among the most important stages of innovative technologies. The intensive development of computing technology and the use of accounting software have significantly enhanced the efficiency of auditing and improved its methods.

Computerized processing of accounting data enables the automated collection and processing of information needed to optimize management across various fields of activity. Improving audit practices in line with market demands is, to some extent, dependent on the digitalization of accounting and analytical systems, the automation of document issuance, and their storage. Most enterprises have reached a stage of development where the number and complexity of business operations have substantially increased, making the search for ways to optimize and reduce audit time more critical, a challenge that software can significantly address.

The most effective solution to this issue is a clear, timely, and reliable methodology for verifying any accounting object. One of the achievements of the digital economy is electronic (computerized) auditing, which involves the verification of accounting operations using specialized software to ensure their accuracy, correctness, completeness, and compliance with current legislation. U.O. Gutsalenko characterizes electronic auditing as the use of modern digital economy technologies to organize auditing activities, including the auditing of financial statements, preparation of audit reports, and related audit services. It should be noted that conducting audits in the context of computer systems is regulated by international auditing standards, such as ISA 401 "Auditing in a Computer Information Systems Environment," ISA 1000 "Interbank Confirmation Procedures," ISA 1001 "Computer Information Systems Environment (CIS) – Standalone Microcomputers," ISA 1002 "CIS Environment – Interactive Computer Systems," ISA 1003 "CIS Environment – Database Systems," and ISA 1009 "Auditing Methods Using Computers." These standards also address audit practices in various information systems environments, assessing audit risks, and outlining the requirements for auditors' specialized knowledge of

computer information systems.

Based on the comparison of the essence of computer information systems in auditing by various scholars, a distinct definition has been derived. Computer Information Systems (CIS) in auditing refer to a software environment that integrates accounting, auditing, and management functions, wherein financial information significant for the audit is processed by an entity, regardless of whether the software is used by the entity or a third party (auditor).[3].

The analysis of the audit software market has shown that such tools, despite their intensive use, have both advantages and disadvantages. It is worth noting that the digitalization of auditing does not fundamentally alter its subject matter or affect its overall goal. Depending on the type, the objective of computerized auditing is:

- to provide management with information regarding the analysis of the accounting system, income and loss forecasting, and financial analysis in the case of internal audits;
- to verify the accounting and reporting systems to provide external users with relevant information in the case of external audits.

The subject of electronic auditing is the automated accounting of business transactions, which confirms the accuracy and legality of financial reports, as well as the determination of the real financial and economic condition of an enterprise, organization, or institution.

The object of auditing depends on the tasks the auditor needs to address, depending on the types of audit activities (audit of financial and economic activities and related audit services).

The tasks of digital auditing include auditing accounting objects, auditing internal accounting control, auditing the security, efficiency, and correctness of accounting information systems, auditing financial stability and solvency, and so on. Computerization of auditing does not fundamentally change accounting methodology. However, the methodology for auditing financial statements of enterprises that use comprehensive computer information systems and accounting software undergoes significant changes, although the overall goal of auditing remains unchanged.[3].

It is important to note that the audit software market in Ukraine is still in the development stage. On the global market, software products such as ACL, IDEA, and SESAM, which are used for electronic auditing, are currently available. This software is suitable for the analysis of accounting and reporting indicators, as well as large volumes of data sets.[3].

Any software used in electronic auditing can be divided into two main components: specialized software and control data. The former is used to verify the content of files and, in some cases, to restore the accounting or tax records of the business entity, while the latter is used to check the correct functioning of computer programs. In the context of economic digitalization, it is also advisable to conduct IT audits, particularly when there are difficulties in the operation of IT infrastructure, software malfunctions, hardware failures, or during significant organizational changes (such as restructuring, decentralization, or the establishment of new branches or divisions).

An IT audit is the process of examining a company's information technology infrastructure to obtain an expert assessment of its state, evaluate

the capabilities of the existing IT system, and identify any shortcomings. To reduce costs and improve the quality and accuracy of IT audit results, the use of specialized software tools is becoming increasingly important.

It should be noted that today, various international organizations, such as ISACA, IAF, ISO, and others, are actively researching aspects of conducting IT audits. Following the relevant guidelines, including ISACA's G3 "Use of CAATs" guidance, IAF's MD 4:2008 "Mandatory Document for the Use of Computer Assisted Auditing Techniques (CAAT) for Accredited Certification of Management Systems," and the ISO/IEC 17021:2006 standard, the classification of professional audit support software-CAAT (Computer Assisted Audit Techniques)-is as follows 115, 116, 117:

- ✓ generalized Audit Software (GAS): General-purpose audit software that allows auditors to test computer files, databases, and networks in compliance with international standards and best global practices;
- ✓ custom Audit Software (CAS): Specialized audit software needed when a client's computer systems are incompatible with GAS tools or when auditors must perform specific tests that GAS tools do not provide;
- ✓ test Data: Software tools for data testing, used by auditors to verify the software controls of a client's computer applications. Auditors conduct simulated tests to validate the relevance of data and assess the procedures for data storage and compliance with information security standards;
- ✓ parallel Simulation: Software for parallel simulation, where the auditor develops a computer simulation to replicate the client's operational programs for audit purposes;
- ✓ integrated Test Facility (ITF): Testing tools that allow auditors to test data directly during the operation of the software applications. Well-known

GAS tools include SAS, Excel, Access, Crystal Reports, Business Objects, and others, equipped with various mathematical, statistical, analytical, and other functions, allowing for the graphical representation of information and the programming of additional features.[2].

In the era of "information and high technologies," information systems play a significant role in the audit process. However, it is important not to overestimate the importance of computer programs in auditing. None of these systems can fully replace an auditor; they are designed merely to assist. The outcome of an audit is influenced to a greater extent by the auditor's experience, skills, and expertise, as well as their ability to effectively leverage the capabilities of information systems.[1].

To enhance the quality of audit services, particularly when auditing debtors and creditors, it is necessary to organize the professional development of auditors in the field of IT auditing. However, considering the trends in the use of information technologies in auditing, several practical challenges arise:

- ✓ specificity of audit activities, including the inability to fully formalize the audit process and the formulation of a professional opinion;
- ✓ diverse software used by the audited enterprise, along with numerous internal analytical registers for accumulating information on the composition and value of the enterprise's assets and liabilities;
- ✓ the need for auditors to conduct on-site audits at the enterprise;
- ✓ the diverse industry specialization of clients served by audit firms.

In conclusion, despite the challenges associated with the use of information technologies in auditing, the integration of information systems is not only a relevant task and a crucial factor for an auditor's success but

also a necessary condition for conducting high-quality audits. Auditors should be involved in the software development process to ensure that key elements of the software are properly tailored to audit needs. Additionally, fostering a favorable investment climate to attract capital for the development of domestic software is advisable. This would help address the unique aspects of business and auditing activities in our country. Ukrainian firms must realize that swiftly adopting information technologies is the key to gaining the necessary competitive advantages in both domestic and international markets.

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THE INFLUENCE OF TECHNOLOGICAL DEVELOPMENT ON CONSUMER BEHAVIOR: A QUALITATIVE STUDY OF ONLINE SHOPPING PLATFORMS

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Technological advancements have revolutionized various aspects of daily life, including the way people conduct economic transactions. The

internet has become an essential tool, enabling more efficient and practical ways of conducting business, particularly through online shopping. The emergence of e-commerce platforms has significantly changed consumer behavior, as people now opt for the convenience of online shopping over traditional methods. The shift in consumer habits can be attributed to several factors, including accessibility, pricing, convenience, and features offered by online marketplaces.

In recent years, online shopping platforms have proliferated, offering a wide range of products at competitive prices, often more affordable than those found in traditional brick-and-mortar stores or shopping malls. As a result, a growing number of businesses are moving their operations online, and consumers are increasingly turning to these digital marketplaces to fulfill their shopping needs. This study aims to explore the factors driving this shift and how online shopping platforms, such as Shopee, influence consumer behavior through their features and offerings.

Methodology

This research employs a qualitative approach, focusing on a literature review to understand the trends and behaviors associated with online shopping. By analyzing various sources, the study seeks to identify the primary reasons consumers prefer online shopping over traditional markets and to evaluate the features that make platforms like Shopee attractive to users. The analysis covers aspects such as convenience, pricing, customer service, and the technological tools available on these platforms.

Discussion

The growing popularity of online shopping can be linked to several key

features that these platforms offer. First and foremost is convenience. Online marketplaces allow consumers to search for and purchase goods without leaving their homes, using only a smartphone or computer. This capability has dramatically changed the shopping experience, as people can now access products from all over the world, at any time of day, without being constrained by physical store hours.

One of the primary advantages of online shopping is the ability to compare prices easily. E-commerce platforms often offer a wide variety of products at competitive prices, and consumers can quickly browse through different sellers to find the best deals. This is particularly evident on platforms like Shopee, where multiple sellers often offer the same products at varying prices. Additionally, online retailers frequently provide discounts, special offers, and promotions, further incentivizing consumers to choose online shopping over traditional options.

For example, Shopee often holds promotional events on specific dates, such as double-digit sale days (e.g., 9.9, 11.11), which have become highly anticipated events for consumers looking to save money on their purchases. During these promotions, Shopee provides additional discounts, free shipping, and other perks, which draw in a significant number of users. Such promotions are especially appealing in an economy where consumers are increasingly budget-conscious.

Moreover, online shopping platforms offer a variety of features that enhance the overall customer experience. On Shopee, for instance, users can easily browse product categories, view product reviews from other buyers, and track their orders in real time. These features create a sense of security and transparency, as consumers can make informed decisions based on the

experiences of others. This contrasts with traditional shopping, where consumers often have limited information about a product until they physically inspect it in-store.

Another factor contributing to the rise of online shopping is the availability of diverse payment methods. Shopee offers various payment options, including credit cards, digital wallets, and cash on delivery. This flexibility allows consumers to choose the payment method that best suits their needs, further simplifying the transaction process.

The Role of Discounts and Promotions

Shopee has become particularly popular among consumers due to its frequent discounts and promotions. Special promotional events, such as those held during major shopping festivals, have a substantial impact on consumer behavior. For example, Shopee's participation in events like Black Friday and its own uniquely branded sales days create a sense of urgency among shoppers. The platform utilizes flash sales, vouchers, and cashback offers to encourage purchases, leading to a spike in sales during these periods.

These marketing strategies are designed to create an enjoyable and rewarding shopping experience. Consumers are drawn to the prospect of saving money, and the competitive nature of these sales events adds an element of excitement. This aspect of online shopping is particularly effective in attracting consumers who might not otherwise have made a purchase. The psychological impact of time-limited offers can spur impulse buying, with many consumers making purchases they hadn't initially planned, driven by the desire to take advantage of limited-time discounts.

Comparison with Traditional Markets

The shift from traditional markets to online platforms is also influenced by the ease of access to a broader range of products. Traditional markets and malls often have a limited selection of goods, constrained by physical space and local availability. In contrast, online shopping platforms like Shopee allow users to access goods from various regions, often providing items that would be difficult or impossible to find in local stores.

Furthermore, the convenience of shopping from home cannot be overstated. For individuals living in urban areas, where traffic congestion and long distances to shopping centers can be a deterrent, online shopping provides a hassle-free alternative. Additionally, in the post-pandemic world, the need for contactless shopping options has further fueled the growth of e-commerce. People are more inclined to shop online due to concerns about health and safety, making online shopping an attractive option for those seeking to avoid crowded spaces.

Another critical difference between online and traditional shopping is the level of customer service. While physical stores offer face-to-face interactions, online platforms provide customer support through live chat, email, and phone services. Shopee, for instance, has a customer service system that assists users with issues related to their orders, refunds, and disputes with sellers. The platform also allows users to rate their shopping experience, providing valuable feedback to sellers and helping to maintain a high standard of service.

Challenges of Online Shopping

Despite its many advantages, online shopping is not without its

challenges. Issues such as product authenticity, shipping delays, and miscommunication between buyers and sellers can negatively impact the shopping experience. Platforms like Shopee have implemented measures to address these concerns, such as offering buyer protection programs that guarantee refunds in case of disputes. However, these issues persist and can sometimes discourage users from fully embracing online shopping.

Additionally, the digital divide remains a barrier for some consumers. Not everyone has access to the internet or the necessary devices to shop online, limiting the reach of these platforms. Moreover, some individuals, particularly older generations, may be hesitant to adopt online shopping due to unfamiliarity with the technology or concerns about online security.

Conclusion

The rise of online shopping platforms like Shopee reflects a broader shift in consumer behavior driven by technological advancements. The convenience, competitive pricing, and user-friendly features of these platforms have made them a preferred choice for many shoppers, surpassing traditional markets in popularity. As the e-commerce sector continues to grow, it will be essential for platforms to address challenges such as product authenticity and customer service to maintain consumer trust and satisfaction.

In conclusion, the integration of technology into daily life has transformed how people shop, and online platforms are at the forefront of this change. As consumers become more accustomed to the benefits of online shopping, the trend is likely to continue, with traditional markets playing a smaller role in the future of retail. Shopee's success in attracting a large consumer base through its features, promotions, and convenient services

exemplifies the growing dominance of e-commerce in the global economy.

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ENHANCING GLASS MELTING PROCESS AUTOMATION USING FUZZY LOGIC: A REVIEW AND FUTURE PROSPECTS

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The automation of industrial processes, particularly in glass melting, presents unique challenges due to the high temperatures and complexity of the involved parameters. The introduction of fuzzy logic offers an innovative approach to addressing these challenges, improving both energy efficiency and product quality. This article reviews the current state of glass furnace automation, evaluates the effectiveness of fuzzy logic systems, and outlines methods for integrating these systems into existing industrial setups. We also explore future trends in automation, including artificial intelligence and machine learning, and propose research avenues for further

improving the efficiency and sustainability of glass production.

In modern industrial settings, automation has become the cornerstone of efficient and reliable production. This is particularly true in industries such as glass manufacturing, where complex processes, high energy demands, and precise control over temperatures and material quality are essential. Glass melting, one of the most critical stages in glass production, presents significant challenges due to the high temperatures (1400°–1600°C) and the dynamic nature of the process. Managing these processes through traditional control systems has proven to be both inefficient and prone to error, leading to increased energy consumption and variability in product quality.

Recent developments in information technologies, particularly the application of fuzzy logic, have shown promise in improving the control of such complex systems. Unlike traditional binary logic systems, which are based on fixed yes/no decisions, fuzzy logic operates on degrees of truth, making it better suited to handling the uncertainties inherent in dynamic industrial processes. This article explores the current state of automation in glass melting furnaces, evaluates the advantages of fuzzy logic control systems, and examines their potential for improving energy efficiency and product quality.

2. The Current State of Glass Furnace Automation

The production of glass involves three main stages: the melting of raw materials, refining (or clarification), and the cooling of the molten glass mass. Each of these stages must be carefully controlled to ensure the consistent quality of the final product. Traditional glass melting furnaces are operated under tightly regulated conditions, with parameters such as fuel and air flow

rates, temperature, pressure, and gas composition being monitored and adjusted in real-time.

Despite these control measures, modern glass manufacturing processes are highly complex, involving numerous interacting parameters that are difficult to model analytically. Consequently, achieving optimal furnace performance remains a challenge. As noted in previous studies【17†source】, the use of traditional control systems based on deterministic models often falls short, as they cannot account for the full range of variables affecting the glass melting process.

3. Challenges in Traditional Control Systems

Traditional control systems in glass manufacturing typically rely on proportional-integral-derivative (PID) controllers, which are effective for linear systems but struggle to maintain optimal control in non-linear and dynamic environments. In the context of glass melting, several factors contribute to the complexity of the process:

Temperature Variability: Glass furnaces operate at extremely high temperatures, which must be maintained consistently to ensure the proper melting and homogenization of raw materials. However, fluctuations in fuel supply, furnace aging, and environmental conditions can lead to significant temperature variability.

Energy Consumption: Glass melting is an energy-intensive process, accounting for a significant portion of production costs. Traditional control systems often fail to optimize energy use, leading to unnecessary energy wastage.

Product Quality: The quality of the molten glass depends on precise

control over the chemical reactions that occur during the melting and refining stages. Traditional systems struggle to manage the complex interactions between temperature, pressure, and material composition, leading to variability in the quality of the final product.

These challenges have prompted the exploration of alternative control systems that can handle the inherent uncertainties and complexities of glass melting more effectively.

4. Fuzzy Logic in Industrial Control Systems

4.1 What is Fuzzy Logic?

Fuzzy logic is a form of many-valued logic that allows for the representation of values that are not strictly true or false, but instead fall within a continuum of possibilities. This makes it particularly well-suited to applications in which there is uncertainty or imprecision, as is often the case in industrial control systems. The theory of fuzzy logic was first developed by Lotfi Zadeh in the 1960s【17†source】, and it has since been applied in a wide range of fields, including process control, robotics, and artificial intelligence.

In the context of glass melting, fuzzy logic allows for more flexible control strategies that can adapt to the dynamic nature of the process. By modeling the relationships between different process parameters (such as temperature, pressure, and material composition) as fuzzy sets, control systems can make more nuanced adjustments to maintain optimal furnace conditions.

4.2 Fuzzy Logic Controllers (FLCs)

A fuzzy logic controller (FLC) operates by converting input variables

(such as temperature and fuel flow) into fuzzy values, which are then processed using a set of predefined rules to generate control outputs. Unlike traditional controllers, which rely on fixed thresholds to trigger actions, an FLC uses linguistic variables (such as "high," "low," "medium") to describe the state of the system, allowing for more gradual and context-dependent adjustments.

The basic structure of an FLC consists of the following components:

Fuzzification: This step involves converting the raw input data (e.g., temperature readings) into fuzzy values, which are represented as degrees of membership in different fuzzy sets.

Inference Engine: The inference engine applies a set of fuzzy rules to the input values, generating a fuzzy output that represents the appropriate control action.

Defuzzification: Finally, the fuzzy output is converted back into a crisp value that can be used to adjust the control system.

One of the main advantages of FLCs is their ability to handle non-linear systems and adapt to changing process conditions. This makes them particularly well-suited to applications such as glass melting, where process dynamics can change rapidly and unpredictably.

5. Applications of Fuzzy Logic in Glass Melting

The application of fuzzy logic to glass melting has been the subject of several studies, which have demonstrated its potential to improve both process efficiency and product quality. Some key areas in which fuzzy logic has been applied include:

5.1 Temperature Control

Maintaining a consistent temperature within the glass furnace is essential for ensuring the quality of the molten glass. Traditional PID controllers often struggle to maintain stable temperatures, particularly when there are rapid fluctuations in fuel supply or furnace conditions. Fuzzy logic controllers, on the other hand, are able to adapt to these changes more effectively by making continuous adjustments to the fuel and air flow rates based on real-time data.

In a study conducted by Mamdani and colleagues【17†source】, fuzzy logic was used to control the temperature of a glass furnace, resulting in more stable temperatures and improved energy efficiency compared to traditional PID controllers.

5.2 Energy Optimization

Energy consumption is one of the biggest cost drivers in glass manufacturing. By optimizing the combustion process and reducing heat losses, fuzzy logic controllers can significantly reduce energy consumption. In addition, fuzzy logic systems can be integrated with advanced sensors and data analytics tools to provide real-time feedback on energy use, allowing operators to make more informed decisions about how to optimize furnace performance.

5.3 Product Quality

The quality of the glass produced in a furnace is heavily dependent on the temperature, pressure, and composition of the molten glass. Fuzzy logic controllers are able to maintain more precise control over these variables, leading to a more consistent product. In particular, fuzzy logic has been

shown to reduce the formation of defects such as bubbles and inclusions, which can significantly affect the strength and optical properties of the glass.

6. Integration of Fuzzy Logic with Other Technologies

While fuzzy logic has proven to be a powerful tool for controlling complex industrial processes, its effectiveness can be further enhanced when integrated with other technologies such as artificial intelligence (AI) and machine learning. These technologies enable control systems to learn from past data and make predictions about future process conditions, allowing for even more precise control.

6.1 Artificial Neural Networks

Artificial neural networks (ANNs) are a type of machine learning algorithm that can be used to model complex relationships between input and output variables. When combined with fuzzy logic, ANNs can help improve the accuracy of control systems by learning from historical data and adjusting the fuzzy rules accordingly. This is particularly useful in glass melting, where the relationships between process variables can be highly non-linear and difficult to model using traditional methods.

6.2 Genetic Algorithms

Genetic algorithms (GAs) are another type of optimization technique that can be used to improve the performance of fuzzy logic controllers. By simulating the process of natural selection, GAs can be used to automatically adjust the parameters of a fuzzy logic controller to optimize its performance. This can be particularly useful in applications where there are multiple conflicting objectives, such as minimizing energy consumption while maintaining product quality.

7. Case Studies and Practical Applications

Several glass manufacturing plants have successfully implemented fuzzy logic controllers, resulting in significant improvements in process efficiency and product quality. One notable example is the use of fuzzy logic to control the glass melting process at a large glass manufacturing plant in Europe. By implementing a fuzzy logic controller, the plant was able to reduce its energy consumption by 15% and improve the quality of its glass products, resulting in fewer defects and higher customer satisfaction.

In another case study, a glass manufacturer in Asia used fuzzy logic to optimize the combustion process in its furnaces. By adjusting the fuel and air flow rates based on real-time data, the company was able to achieve more stable furnace temperatures and reduce its energy consumption by 10%.

8. Future Trends in Glass Furnace Automation

As technologies such as AI and machine learning continue to advance, the role of fuzzy logic in industrial automation is likely to expand. In the future, we can expect to see more intelligent control systems that are capable of learning from data and making real-time adjustments to optimize process performance.

One area of particular interest is the integration of fuzzy logic with the Internet of Things (IoT). By connecting furnaces to a network of sensors and devices, it will be possible to collect and analyze vast amounts of data on process conditions, allowing for even more precise control. This will enable manufacturers to optimize their processes in real-time, reducing energy consumption and improving product quality.

9. Conclusion

The application of fuzzy logic to glass melting processes offers significant advantages in terms of both process efficiency and product quality. By allowing for more flexible and adaptive control strategies, fuzzy logic can help manufacturers overcome the challenges of traditional control systems and improve the performance of their furnaces. As technologies such as AI and machine learning continue to evolve, the potential for fuzzy logic in industrial automation will only grow, offering new opportunities for manufacturers to optimize their processes and reduce their environmental impact.

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USER EXPECTATIONS AND SERVICE DELIVERY IN THE UGM LIBRARY'S REFERENCE AND PERIODICAL PUBLICATION SERVICES: A QUALITATIVE ANALYSIS

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The role of libraries in the digital era continues to evolve, yet the fundamental relationship between the library and its users remains critical. Libraries are now expected not only to provide access to a wide range of information resources but also to meet the increasing expectations of users concerning the quality of services provided. The measure of success for a library, especially in a large academic institution such as Universitas Gadjah Mada (UGM), lies in the extent to which these expectations are fulfilled, and how satisfied users are with the library's products and services. UGM Library's Reference and Periodical Publication Unit has been striving to meet these needs by offering a variety of resources and services designed to fulfill the information demands of its users. However, it is important to analyze to what extent these services meet user expectations and to explore ways in which the library can leverage modern technological tools to enhance service delivery.

This study aims to investigate user expectations regarding the products and services offered by UGM Library's Reference and Periodical Publication Unit. By focusing on user-oriented service provision, this research seeks to understand how users perceive the quality and relevance of the library's offerings and what improvements can be made. As libraries face increasing competition from digital platforms and online databases, it becomes crucial to not only provide high-quality resources but also deliver them in ways that meet the evolving expectations of users. Libraries must now offer services

that are not only efficient but also user-friendly, intuitive, and aligned with modern technological trends.

Research Methodology

This study employs a qualitative descriptive research approach, utilizing interviews with eight users of the Reference and Periodical Publication Unit as the primary method of data collection. These users were selected based on their familiarity with the unit's services and their frequency of use, making them ideal candidates for providing feedback on user expectations. To ensure data validity, source triangulation was employed. This involved comparing data from various sources, including interviews with key informants, observations conducted at the library, and documentation related to library services and user interactions.

Data analysis followed a three-stage process: data reduction, data presentation, and drawing conclusions or verification. Data reduction involved selecting, focusing, and simplifying the raw data obtained during the interviews and observations. The presentation stage organized the reduced data into a coherent narrative that could be analyzed and interpreted. Finally, conclusions were drawn based on the patterns and themes that emerged from the data, providing insights into user expectations and the degree to which these expectations were met by the library services.

Findings and Discussion

The results of the study reveal that user expectations for the Reference and Periodical Publication Unit's products and services are generally higher than the current offerings. Users expressed a desire for more comprehensive

and easily accessible resources, faster service delivery, and greater availability of digital materials. Despite the library's efforts to maintain a broad and up-to-date collection, users indicated that the scope of the available resources sometimes fell short of their expectations, particularly when it came to accessing niche or highly specialized materials.

One key area identified for improvement is the speed and efficiency of service delivery. Users highlighted that while the staff was generally helpful and knowledgeable, the process of locating and retrieving materials could be slow, particularly during peak usage times. This issue was exacerbated by the limited availability of certain periodicals, which required users to wait for access to physical copies rather than being able to access them digitally.

In addition to these concerns, users expressed a need for more intuitive and user-friendly digital interfaces. While the library has made efforts to digitize many of its resources, the online platform was perceived as outdated and difficult to navigate. Users noted that searching for specific periodicals or references could be cumbersome, with many reporting that they often resorted to external databases and search engines to find the information they needed. This highlights a significant gap between user expectations and the current state of the library's digital services.

The Role of Technology and Computer Modeling in Enhancing Library Services

As libraries move further into the digital age, the use of computer modeling and advanced technologies can play a critical role in enhancing the efficiency and effectiveness of library services. One area where computer modeling can have a significant impact is in optimizing resource allocation and predicting user demand. By using algorithms to analyze user behavior

and predict future trends, libraries can better manage their collections, ensuring that the most in-demand resources are readily available.

In the context of UGM Library, computer modeling could be used to improve the Reference and Periodical Publication Unit's ability to meet user needs. For example, by analyzing past borrowing data and trends in academic publishing, the library could predict which periodicals or references are likely to be in high demand in the future. This would allow the library to prioritize the acquisition of these materials, reducing wait times for users and ensuring that the most relevant resources are available when needed.

Moreover, advanced data analytics can help libraries better understand user preferences and tailor their services accordingly. By analyzing usage patterns, libraries can gain insights into which resources are most frequently accessed and which are underutilized. This information can be used to adjust the library's collection development strategy, ensuring that resources are allocated in a way that maximizes user satisfaction.

Another area where technology can enhance library services is through the implementation of automated systems for managing user requests and inquiries. By using artificial intelligence (AI) and machine learning algorithms, libraries can create more efficient systems for handling user queries, reducing response times and improving the overall user experience. For instance, AI-driven chatbots could be used to answer common questions about library services or assist users in navigating the digital platform, freeing up staff to focus on more complex tasks.

In addition to these practical applications, computer modeling can also be used to simulate different scenarios and assess the potential impact of

new policies or services before they are implemented. For example, the library could use simulations to evaluate the effectiveness of proposed changes to the layout of the Reference and Periodical Publication Unit or to test the feasibility of new service models, such as extended digital lending or remote access to physical materials.

Conclusion

The findings of this study indicate that while UGM Library's Reference and Periodical Publication Unit provides valuable resources and services to its users, there is significant room for improvement, particularly in terms of meeting user expectations for speed, accessibility, and digital functionality. By incorporating advanced technologies such as computer modeling and AI, the library can enhance its service delivery, making it more efficient, user-friendly, and responsive to the evolving needs of its users.

As libraries continue to adapt to the challenges and opportunities of the digital age, it is crucial that they remain user-oriented, continually assessing and responding to the expectations of their users. By leveraging modern technology and data-driven insights, UGM Library can improve its services and ensure that it continues to meet the high standards expected by its users.

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UNSTEADY AERODYNAMICS OF MOSQUITO FLIGHT AND THEIR APPLICATION TO LOW-DENSITY ENVIRONMENTS

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In terms of their flight and unique aerodynamic characteristics, mosquitoes have emerged as a new subject of interest in aerodynamics and bio-inspired robotics. Despite being vectors for the world's most dangerous diseases, mosquitoes demonstrate remarkable flight capabilities with flapping frequencies between 600 and 800 Hz and stroke amplitudes of 40 to 45°. Unlike most insects, mosquitoes use rotational drag, wake capture, and the trailing-edge vortex for lift, making them of particular interest for the design of small flying robots, especially for flight in low-density atmospheres such as on Mars. This paper systematically reviews the aerodynamic mechanisms involved in mosquito flight and explores the implications for bio-inspired robotics.

Introduction

The mosquito (Culicidae) is one of the most notable examples of insects with unique aerodynamic properties. Their flight mechanism and aerodynamics significantly differ from other insects, which generally rely on large stroke amplitudes and leading-edge vortex lift generation. This has made mosquitoes an important model for studying unsteady aerodynamics, especially in low Reynolds number regimes, which are relevant for both biological flight and bio-inspired robotics.

Flapping Characteristics of Mosquitoes

Mosquitoes maintain flight by flapping their long, slender wings at frequencies ranging from 600 to 800 Hz. The amplitude of their wing strokes is significantly lower than that of other flying insects, measuring only between 40° and 45°. This is in stark contrast to the stroke amplitudes of over 120° observed in larger insects like dragonflies. Despite these differences, mosquitoes achieve stable flight using several unconventional aerodynamic mechanisms, which we will explore below.

Rotational Drag

One of the primary lift-generating mechanisms in mosquitoes is rotational drag. As the wings rotate at the end of each stroke, the drag forces generated contribute significantly to lift. This force can be modeled as:

$$F_{\text{drag}} = \frac{1}{2} C_D \rho A v^2,$$

where C_D is the drag coefficient, ρ is the air density, A is the surface area of the wing, and v is the velocity of the wing. Rotational drag is particularly effective in high-frequency, low-amplitude wing flapping.

Wake Capture and Trailing-Edge Vortex

Wake capture is another mechanism utilized by mosquitoes. As the wing completes one stroke, it moves back into the wake generated by the previous stroke, re-energizing the wing with aerodynamic forces. This process involves a trailing-edge vortex, which enhances the lift generated during stroke reversal. The mathematical formulation for wake capture can be described through the vorticity equation, emphasizing the significance of unsteady vortex dynamics in mosquito flight:

$$\frac{\partial \omega}{\partial t} + (\mathbf{u} \cdot \nabla)\omega = (\omega \cdot \nabla)\mathbf{u} + \nu \nabla^2 \omega,$$

where ω represents the vorticity, $\mathbf{u}$ is the velocity field, and ν is the kinematic viscosity.

Added Mass Effect

The third major aerodynamic mechanism at play in mosquito flight is the added mass effect. When the wing accelerates during flapping, it must move not only the mass of the wing but also a portion of the surrounding air. This added mass effect increases the inertia of the wing and can enhance the generation of unsteady forces. The added mass can be calculated using:

$$m_{\text{added}} = \rho V_{\text{displaced}},$$

where $V_{\text{displaced}}$ is the volume of air displaced by the wing during its stroke. This effect plays a critical role in high-frequency flight regimes.

Implications for Bio-Inspired Robotics

These aerodynamic mechanisms in mosquito flight hold significant potential for the design of bio-inspired micro aerial vehicles (MAVs). MAVs

that mimic the high-frequency, low-stroke amplitude flight of mosquitoes could operate efficiently in low-density atmospheres such as Mars. The rotational drag, wake capture, and added mass effect observed in mosquito flight can be adapted to improve the performance of these vehicles in environments where traditional fixed-wing or rotary-wing drones struggle.

Flight in Low-Density Environments

One of the most challenging aspects of flight on Mars is the low atmospheric density, which is about 1% of Earth's atmosphere. This makes lift generation difficult for conventional flying mechanisms. However, mosquito-inspired MAVs could take advantage of the unique aerodynamic forces described above. In particular, the high-frequency, low-stroke flapping observed in mosquitoes may prove advantageous in such environments, where traditional lift mechanisms are less effective.

State-of-the-Art Insect-Inspired Robots

Several insect-inspired robots are already under development, mimicking various aspects of biological flight. However, few of these designs replicate the aerodynamic characteristics of mosquito flight. Recent advances in micro-robotics have led to the development of robots capable of high-frequency flapping, but improvements are needed in terms of energy efficiency and control. The mosquito-based model offers a promising direction for achieving these goals, especially for missions to low-density atmospheres.

Conclusion and Future Work

In this paper, we have systematically reviewed the unique unsteady aerodynamic mechanisms that allow mosquitoes to achieve stable flight,

despite their small size and low stroke amplitudes. These mechanisms, particularly rotational drag, wake capture, and added mass effect, provide significant insights for the development of bio-inspired MAVs. Future work will focus on further refining mosquito-inspired designs for use in low-density environments such as Mars, where their efficiency could provide a meaningful advantage over existing drone technologies.

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TOY BOOKS AS EDUCATIONAL TOOLS AND THE USE OF MAGNETIC VINYL IN THEIR PRODUCTION

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Toy books play a significant role in fostering a child's curiosity about

the world and helping them acquire various useful skills. For example, they enable easy learning of letters, numbers, colors, and shades, as well as the development of logic and associative thinking. Therefore, it is crucial to introduce children to reading from an early age. Even children under one year of age can perceive some books. Modern books for young children promote the improvement of visual perception, the development of tactile senses, and the child's interest in the external world. Toy books can sing songs, speak in different voices, be bathed, and even be slept on. They can teach a child how to tie shoelaces, tell time, solve different problems, and much more. Most importantly, they introduce the child to books and cultivate a love for reading.

The concept of toy books dates back several centuries and has since evolved, acquiring a range of new features. Today, there are various types of toy books: folding books, pop-up books, panorama books, interactive books, board books, movie books, puzzle books, and musical books, among others. This is not an exhaustive list, and it continues to grow.

An essential area of research in the printing industry is the relationship between new materials and technologies. New materials have become potential means of creating the structural forms of children's books. Over the past two decades, the production of children's books using unconventional materials has surged, especially for toy books. New materials such as vinyl, plastic, polyethylene, natural fiber fabrics, fur, designer cardboard, and synthetic papers have spurred the development of innovative structural solutions for children's toy books.

These products have unique characteristics that must be considered during the production process. The complexity of designing these editions,

along with the introduction of additional technological operations, significantly increases their production costs. However, it is the original construction, additional decorative elements, and creative authorial solutions that ensure consistent consumer demand.

In the present work, a toy book has been developed as part of the series "Old Fairy Tales in a New Way". A key feature of these books is the use of magnetic vinyl for additional elements, such as fairy tale characters. The book is designed so that children can explore the story while simultaneously attaching magnetic characters to a magnetic page (see Figure 1). The child can also create their own fairy tales on a special magnetic field insert.

Thus, for the proposed children's book, the form of the edition is as important as the materials used. To shape the game characters, die-cutting using a stencil form is employed. Despite the labor-intensive production process, the toy book market continues to expand, utilizing not only original design solutions but also new materials and technologies.

Material Characteristics of Magnetic Vinyl

Magnetic vinyl is a material that combines the flexibility and durability of traditional vinyl with the magnetization properties of iron oxide particles. This material is particularly suitable for applications where interactive or detachable elements are required, such as in toy books. The physical and mechanical characteristics of magnetic vinyl include its flexibility, which allows it to be bent or folded without breaking, as well as its strong magnetic properties, which ensure that magnetic elements stay in place during interaction. Additionally, the material is lightweight, water-resistant, and capable of withstanding repeated handling, which makes it ideal for children's books that require durability.

Magnetic vinyl can be easily cut into various shapes and sizes, making it versatile for creative designs. Its ability to hold magnets in place on both flat and slightly curved surfaces adds to its appeal in interactive educational materials. Furthermore, its ability to be laminated or printed upon allows for colorful and engaging designs that attract children's attention while maintaining high functional quality. The material's physical resilience and ease of cleaning (it can be wiped down with a damp cloth) make it particularly suitable for toys and books that are subjected to frequent use by young children.

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