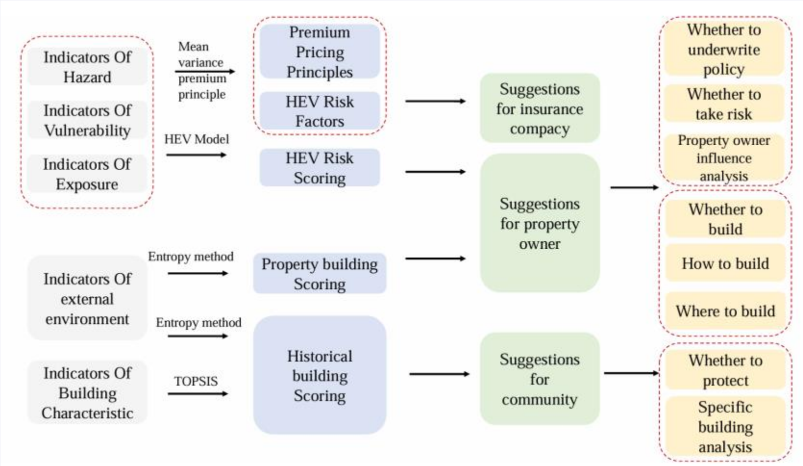
01 | Regional Risk Assessment Model Based on HEV Indicators

——2024 Mathematical Contest in Modeling | Team Leader & Lead Programmer

Problem

As global warming increases and the climate system becomes more volatile, more and more extreme weather disasters are occurring around the world, causing significant losses for property owners, communities, and insurance companies. The world has endured "more than 1 trillion dollar in damages from more than 1,000 extreme-weather events in recent years." Based on the frequent occurrence of weather disasters, many insurance companies and communities have responded with initiatives.

However, due to the lack of the current assessment system, it is still impossible to completely eliminate the impact of weather disasters on the above subjects. Therefore, it is necessary to build a model to reflect the risk of weather hazards and make recommendations for real estate owners and community owners.



Our Work

1

Firstly, we collect data of indicators of hazard, vulnerability, exposure. By mean variance premium principle and building HEV model, we find out Area's premium pricing principles and risk factors, scoring. Then we use our result to make suggestions for insurance company.

2

Secondly, we collect data of indicators of external environment. Using entropy method, we find out property building scoring. Combined with HEV risk scoring, we build up property developer decision making model and make suggestions for them.

3

Lastly, we collect data of indicators of building characteristic. With entropy-method and TOPSIS, we get the scoring of historical building. Then we build a model for community to help them decide whether to protect a building and so on. At the end weapply our model to a specific building and make assessment.

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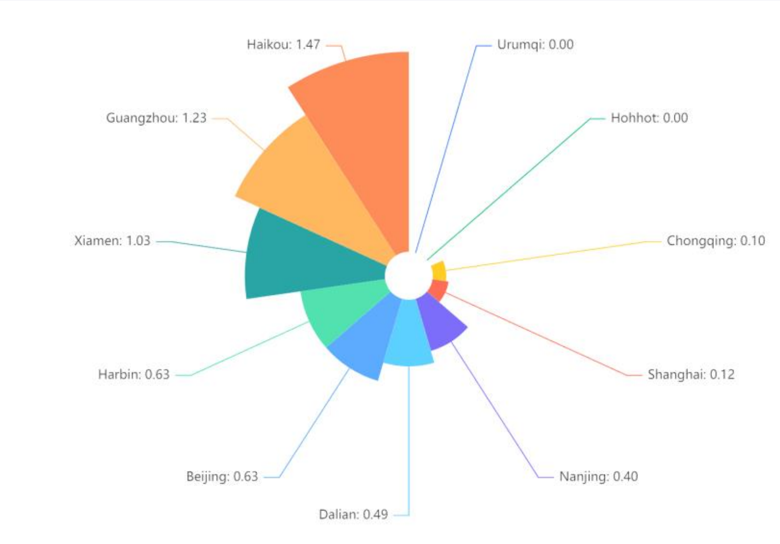
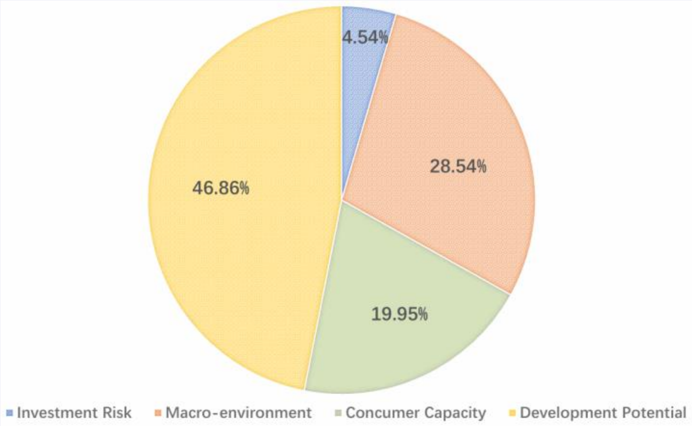


Indicators of typhoon incities in China——From HEV Model

Application

we applied our preservation model to evaluate and propose protection measures for the Confucius Hall in Lingshui County, Hainan Province, China. The model assessed the building's economic, cultural, social, and historical values, revealing that its community and economic values were the highest. Given the frequent typhoons causing structural erosion, we recommended in-situ preservation, including immediate protective measures such as security education for staff, constructing waterproof barriers, and coating the building with waterproof materials. Our detailed plan ensured the protection of this significant landmark while considering the climatic challenges of the region .

Pie chart——Weight Of Indicators Of Decision Model



Honor

Our paper achieving a top <u>2%</u> score among all participating teams around the world and earning the <u>Finalist</u> award.

02 | Enhancing-TransUNet

Problem

The primary issue is that CNNs, while effective at capturing local features, struggle with long-range dependencies and global contextual information. Conversely, Transformers excel at recognizing long-range dependencies through self-attention mechanisms but lack the ability to capture fine-grained local details. This limitation hinders their performance in complex image segmentation tasks.

Design

To address these limitations, I proposes "Enhancing-TransUNet," a hybrid model that integrates UNet++, known for its enhanced local feature extraction through nested skip connections, with Vision Transformers, which provide superior global context understanding. This model combines the strengths of both architectures, using CNNs for detailed local feature extraction and Transformers for capturing global dependencies, ensuring precise and robust image segmentation.

Contribution

I introduces a novel hybrid model, Enhancing-TransUNet, which effectively merges the strengths of CNNs and Transformers to improve image segmentation performance. This model demonstrates significant performance enhancements over existing architectures, such as UNet and TransUNet, through advanced architectural techniques like deep supervision and nested skip connections, providing a balanced approach to capturing both local and global features in images.

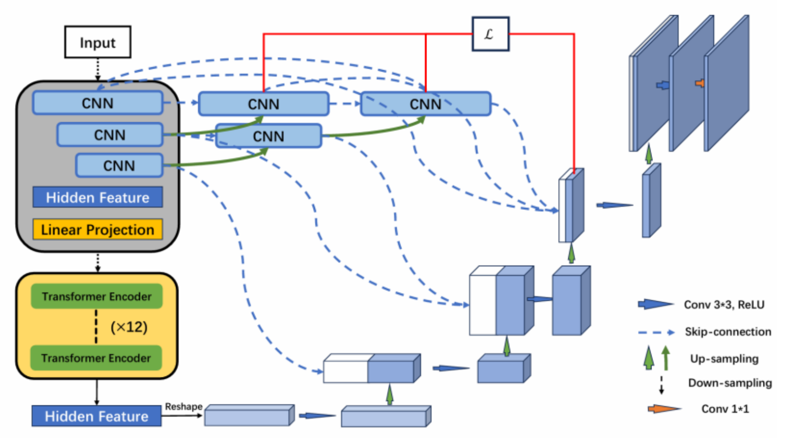


Fig. 1. Overview of the Enhancing-TransUNet framework.

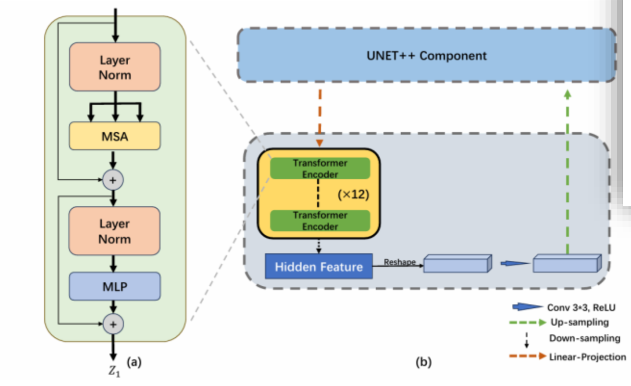


Fig. 3. The framework of the Transformer component within the Enhancing-TransUNet model.(a)The architectural configuration of the Transformer encoder.(b)Process depiction of reshape and up-sampling

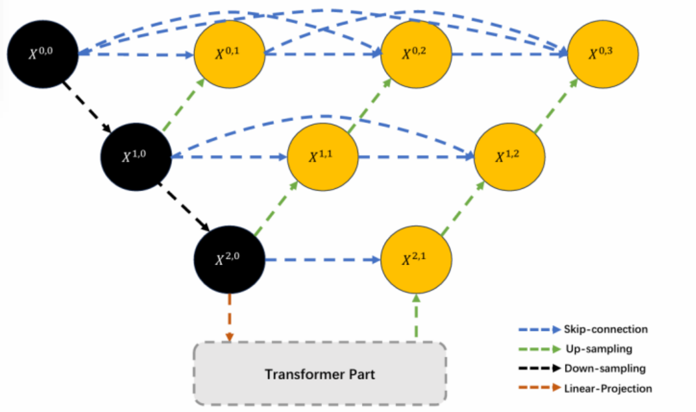
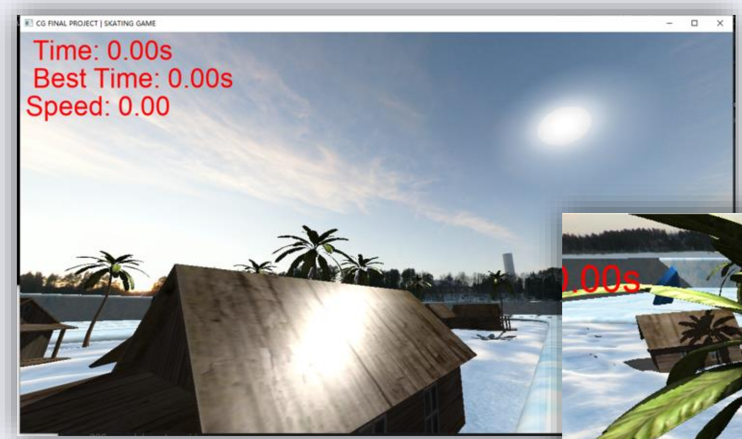


Fig. 2. The framework of the UNet++ component within the Enhancing-TransUNet model.

03 | 3D Skiing Game Development Using OpenGL and C++

Introduction

This project is a 3D third-person skiing racing game developed using the OpenGL library and C++. Players control a character using keyboard inputs to race around an elliptical track. The game records the time for each lap and displays the shortest duration. The track features speed boosters and boulder-shaped obstacles, adding to the challenge. The project involves extensive computer graphics knowledge, as it requires building characters, game scenes, and various game mechanics from scratch using C++.



Blinn-Phong illumination

My Work

1 Implemented the Blinn-Phong illumination model to perform ambient, diffuse, and specular light calculations, bringing the game to life with intricate details and realistic textures.

2 Achieved and optimized shadow effects using the PCF algorithm, eliminating the aliasing phenomenon and improving the visual experience of the game.

2 Implemented character movement and collision, enabling players to control the character for complex movements and interactions.

Without PCF

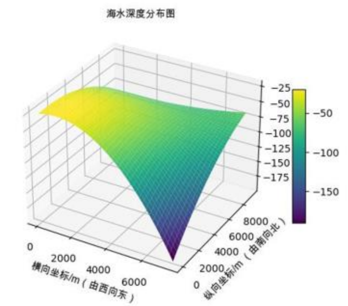
With PCF

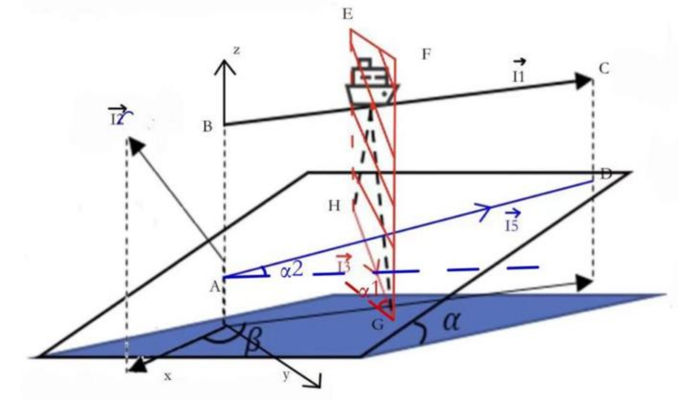
04 | Multibeam Survey Line Problem of Survey Vessels Based on Analytic Geometry and Optimization Algorithms

——2023 China Undergraduate Mathematical Contest in Modeling | Team Leader & Lead Programmer

Problem

We addresses the multi-beam surveying line problem for measurement ships. The key challenges involve optimizing the surveying lines to cover the seabed efficiently while accounting for various depths and slopes. The problem is to find an optimal set of surveying lines that minimize total surveying distance while ensuring sufficient overlap and coverage.





Contribution

1.**Mathematical Models**: Development of precise models for calculating beam coverage and overlap in both 2D and 3D spaces.
2.**Optimization Techniques**: Application of optimization algorithms, such as those in Python's scipy.optimize library, to solve for the shortest total surveying line length under given constraints.
3.**Practical Implementation**: Demonstration of how these models can be applied to real-world surveying tasks, resulting in efficient and effective survey line planning that improves coverage and reduces redundancy.

Design

We designs mathematical models for different scenarios:
1.2D Plane Model: Uses geometric relations to solve for beam coverage width and overlap rates between lines.
2.3D Space Model: Extends the 2D model to three dimensions using vector operations to calculate depths and beam coverage at various points.
3.Optimization Model: For a rectangular sea area, it uses decision variables like surveying line spacing and direction to minimize total line length while meeting overlap constraints.

Honor

Our paper achieving a top 15% score among all teams and being awarded the Second Prize in Guangdong Province.