Research on Innovative Art and Design of Residential Environments in Northeast China's Rural Revitalization Based on AIGC

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Abstract: Amidst the crucial advancement of the Rural Revitalization Strategy within the unique socio-economic and ecological context of Northeast China, traditional residential architecture confronts a complex "triple dilemma": the accelerating fracture of cultural genetic codes, persistent lag in ecological performance, and an increasingly severe mismatch with evolving functional demands. This study pioneers the application of Artificial Intelligence Generated Content (AIGC) technology to the design and renovation of rural dwellings in cold regions, offering bespoke solutions. By constructing a comprehensive iterative design framework termed "Data Collection → Intelligent Generation → User Participation and Feedback," this research achieves three transformative outcomes: (1) the digital translation and parametric reconstruction of intangible regional cultural elements, (2) the algorithmic optimization and intelligent modeling of climate-responsive building systems, and (3) the precise, data-driven response to the multifaceted needs of contemporary farmers. Rigorous empirical studies conducted across multiple pilot villages demonstrate compelling results: AIGC integration enhanced the cultural distinctiveness and resonance of rural dwellings by over 45% (e.g., a surge of 70% in occupancy rates for Manchu cultural homestays), achieved significant reductions in heating energy consumption ranging from 38% to 60% (e.g., verified household heating cost savings of 60%), and substantially reduced the incidence of safety accidents among elderly residents by 60% following targeted age-friendly modifications. Crucially, this research reveals that AIGC technology transcends its role as a mere technical enabler, it acts as a dynamic bridge connecting historical traditions with modern innovation, ultimately forging a new paradigm of "Technology Empowering Cultural Continuity, Design Responding to People's Livelihood Realities" for sustainable rural revitalization. This paradigm provides a scalable solution for rural communities globally facing analogous pressures, offering a path to enhance livability and economic viability while safeguarding cultural identity.

1. Introduction

The fertile black soil region of Northeast China (Dongbei) serves as a strategic cornerstone for national food security. Its comprehensive revitalization is not merely an economic imperative but a multidimensional systemic project integrating cultural preservation, ecological restoration, and socio-economic development[1]. Currently, rural housing in this region is undergoing rapid yet often disorderly modernization. The widespread and uncritical replication of standardized urban housing models has led to a concerning homogenization of village landscapes, resulting in the near-extinction of centuries-old indigenous architectural wisdom. Examples include the Manchu "Pocket House" (Koudai Fang), optimized for wind protection with its enclosed courtyard form and efficient thermal mass, and the ingenious Korean ethnic "Ondol" (Wentu) integrated floor heating system. Compounding this, the region's exceptionally harsh continental climate—characterized by prolonged, bitterly cold winters (frequently dropping below -30°C) and humid summers—exacerbates the energy burden in thermally inefficient structures. Simultaneously, design paradigms detached from agricultural production cycles and household livelihood needs constrain the potential for diversified rural industries and entrepreneurship.

Consequently, a core challenge emerges: How can irreplaceable "nostalgia" (Xiangchou) and cultural identity be safeguarded amidst necessary technological innovation to achieve authentic,

environmentally sustainable, and culturally rooted development? The groundbreaking integration of advanced AIGC technologies—encompassing Generative Adversarial Networks (GANs), Large Language Models (LLMs), Physics-Informed Neural Networks (PINNs), and multimodal data fusion—brings revolutionary potential and offers unprecedented solutions for reimagining rural housing design:Through the transformation of intangible cultural heritage (ICH) elements like patterns, structures, and spatial narratives into quantifiable, reconfigurable digital assets, generation and cultural decoding become feasible,Leveraging predictive algorithms and simulation engines (e.g., EnergyPlus, CFD) to model and optimize building physics for extreme climates deep learning for environmental optimization,By synthesizing user input, behavioral data, and functional requirements, customized design solutions can be generated, achieving precision in co-creation and data-driven participatory design.

Based on extensive field surveys conducted across 42 villages in Liaoning, Jilin, and Heilongjiang provinces (2022-2024) and the implementation of four empirical pilot projects, this paper explores the transformative role of AIGC in: Reviving dormant traditional building wisdom through digital restoration and adaptive reuse, Reconstructing integrated living ecosystems that harmonize human comfort, resource efficiency, and environmental resilience, Catalyzing the co-evolution of rural spatial organization and livelihood systems through the innovative concept of "Growable Dwellings" (homes designed with inherent capacity for functional adaptation over time). The ultimate objective is to provide replicable, technologically robust pathways and a foundational theoretical framework for leveraging digital innovation to achieve a genuinely sustainable and culturally prosperous rural future.

2. The Triple Realistic Dilemma of Northeast Rural Housing: Cultural Erosion, Ecological Lag, and Demand Mismatch

2.1 Cultural Erosion: The Vanishing Vernacular Landscape

The erosion of cultural identity is starkly visible within Northeast China's diverse ethnic landscape. In Hetu Ala Village, Xinbin Manchu Autonomous County, Liaoning, Zhao Jingchun, a 68-year-old ICH inheritor, squatted amidst building ruins at dawn, clutching a faded "Suolun Pole" (Suolun Gan)—once a sacred totemic pole central to Manchu cosmology and family lineage. "Only 42 out of 327 households still retain the Suolun Pole," he lamented, his voice heavy with resignation. "Young families say it 'takes up space,' preferring to install solar panels instead." This poignant scene is not an isolated case. In Korean ethnic communities scattered across Yanbian, Jilin, detailed surveys reveal a severe shortage of skilled craftsmen: only 47 masters proficient in constructing authentic "Ondol" heating systems remain, averaging over 68 years old. The generational disconnect is starkly evident in the ancestral home of the Jin family in Mao'ershan Village, Yanji City. There, the exquisite wooden frame of the traditional Korean "Moon Window" (Dalchang)—a symbol of harmony and protection—has been unceremoniously replaced by generic, mass-produced aluminum alloy windows. "Grandmother says it symbolizes the full moon protecting the household," remarked 19-year-old Jin Minzhi with a shrug, "but to me, it looks just like a city bay window. It doesn't feel special anymore."

Quantitative analysis paints a severe and undeniable picture: In residential renovation projects within Northeast China's characteristic ethnic areas, only 18% consciously incorporated identifiable regional cultural elements. A staggering 78% of newly built farmhouses directly replicated generic urban commercial housing styles. Iconic indigenous layouts, such as the Manchu "Pocket House" courtyard arrangement or the Korean intricate "Ten Thousand Character Kang" (Wanzikang – the long, serpentine heated bed platform central to family life), are preserved in less than 5% of existing old houses. This cultural erosion extends far beyond the loss of architectural symbols to the fragmentation of associated lifestyles and intangible practices. In Daur ethnic settlements near Qiqihar, Heilongjiang, traditional "Yalusi" dwellings (Yalusi) with their distinctive slanted-pole structures ("Xieren Zhu") are rapidly disappearing, replaced by flat-roofed concrete boxes devoid of character. The once ubiquitous "Egedu Chukuer" (Egedu Chukuer), a beautifully crafted

multi-tiered storage shelf designed specifically for displaying hunting trophies and storing tools, is now often used merely to hold anonymous e-commerce delivery boxes. Old man E Wenzhi, his weathered hand stroking the smooth but impersonal latex-painted wall, sighed deeply, "The children no longer know how to prepare or apply the animal skin poultices that kept our ancestors warm through the fiercest blizzards. Those deer hide cushions we used? Replaced by mass-produced fabric sofas from the city. The warmth isn't the same, and the stories are gone." This represents a profound rupture in the transmission of embodied knowledge and cultural meaning intrinsically linked to the built environment, severing the vital connection between place, people, and their shared history.

2.2 Ecological Lag: The High Cost of Thermal Inefficiency

The extreme thermal demands of Northeast China's climate expose severe deficiencies in both aging traditional structures and poorly adapted modern rural buildings. [2]On a frigid -25°C winter morning in Lanxi County, Suihua City, Heilongjiang, farmer Wang Guilan paced her drafty living room bundled in three thick layers of clothing, the indoor thermometer stubbornly showing only 14°C despite the roaring coal stove. She tapped the thin, poorly insulated exterior wall with a sense of frustration: "No real insulation, just bricks and plaster. Last winter alone, we burned over 3 tons of coal just to keep this one room barely tolerable, costing us 2,800 yuan—that's nearly twice what my cousin pays for comfortable central heating in her Harbin apartment!" Scientific thermal audits conducted across the region confirm this is a systemic and costly problem: despite significantly lower comfort levels, per-household winter heating energy consumption remains 25%~40% higher than equivalent urban apartments, with practical applications of renewable energy solutions often hampered by the extreme cold and logistical challenges.

The pursuit of superficially "modern" aesthetics frequently exacerbates these fundamental problems. In a so-called "European-style" villa cluster constructed near Harbin, large areas of visually appealing but thermally inefficient single-glazed windows were chosen primarily for their appearance. This resulted in indoor temperatures plummeting to a bone-chilling 12°C during severe cold snaps. Desperate farmers were forced to seal these elegant windows with layers of plastic sheeting and tape, creating a stark visual paradox described by one visitor as: "Looking like castles from afar, but feeling like plastic greenhouses up close." Summer also brings significant thermal challenges, often overlooked. In Dandong, Liaoning, a newly built flat-roofed concrete house, lacking adequate roof insulation or ventilation design, saw indoor temperatures soar to a stifling and oppressive 32°C during a June heatwave. Farmer Zhang Jianjun described the profound discomfort: "Sleeping feels like being trapped in a steamer basket. Running the air conditioner all night is financially ruinous, but you simply can't sleep without it due to the relentless heat and humidity." This year-round thermal discomfort imposes heavy economic and health burdens on rural households, draining limited resources and diminishing overall well-being and productivity.

2.3 Demand Mismatch: Disconnection from Life and Livelihood

Modern rural housing design frequently overlooks the intrinsic, practical link between living spaces and the realities of agricultural production or evolving family lifestyles. In Dawa District, Panjin City, Liaoning, farmer Chen Guangcai surveyed his newly built, architect-designed "rustic chic" home with visible frustration: "The architect only thought about making it look 'country charming' for pictures, completely forgetting I need covered, accessible space for storing and maintaining my large combine harvester. Three times during the last critical harvest season, precious grain got soaked by sudden rain before I could move it inside, leading to spoilage and financial loss." Comprehensive surveys covering thousands of households indicate a clear gap: 72% of Northeast farmers explicitly desire homes that seamlessly integrate essential functional spaces such as dedicated farm tool storage, large covered areas for crop sorting and drying, and temperature-controlled spaces suitable for winter seedling cultivation or small-scale agro-processing.

However, only a disappointing 28% of existing or newly built residences adequately incorporate these essential, livelihood-supporting functions. Safety and accessibility for the rapidly aging rural

population represent another critical and often dangerous mismatch. In a remote mountain village near Tonghua, Jilin, 65-year-old Li Shuzhen suffered a debilitating hip fracture after a fall at home: "The entrance steps were far too high and steep, and the bathroom was located much too far from the bedroom down a cold corridor. A simple ramp with sturdy handrails installed that very night could have easily prevented my fall and this terrible pain." Statistics reveal a startling and concerning gap: 73% of rural homes housing elderly residents lack any form of age-friendly modification whatsoever. The availability of basic accessibility features like gentle ramps, secure handrails, or step-free showers is tragically below 10%. Perhaps most detrimental to the long-term goals of revitalization is the fundamental disconnection between housing design and emerging rural industries like tourism and craft production. In Mudanjiang, Heilongjiang, farmer Wang Xiuying invested her savings into converting her family home for tourism, only to find the traditional layout utterly unsuitable: "No private bathroom for guests, kitchen far too small for preparing group meals—tourists ended up staying in city hotels miles away, leaving us empty." When housing design fails to align with actual livelihood needs and emerging economic opportunities, it not only degrades daily quality of life but also actively stifles the potential for rural entrepreneurship and diversified income streams, directly hindering the core objectives of sustainable revitalization and community prosperity.

3. AIGC's Transformative Solutions: Cultural Renaissance, Ecological Intelligence, and Demand Responsiveness

3.1 Cultural Renaissance: Digitizing Heritage, Reigniting Identity

AIGC technology provides powerful, innovative tools for digitally preserving, analyzing, and creatively reintegrating endangered cultural elements into contemporary, functional design. Within the "Digital Vernacular Gene Bank" laboratory at a leading Shenyang university, engineers utilized advanced scanning techniques (high-resolution photogrammetry, LiDAR) and sophisticated AI processing pipelines to meticulously decompose intricate Manchu "Momo Ren" paper-cutting patterns (Momo Ren Jianzhi) into precise vector elements, transforming them into adjustable parametric modules. Similarly, complex Korean "Huiwen" (Huiwen – intricate geometric window lattice) patterns were analyzed for their underlying mathematical principles and then algorithmically recombined to generate culturally resonant yet entirely new variants. The ingenious structural logic of the Daur "Xieren Zhu" (Xieren Zhu – slanted pole) framework was carefully reverse-engineered into adaptive 3D structural models suitable for modern construction. Crucially, each digitized element was meticulously tagged with its rich cultural narrative, traditional material specifications, original construction logic, and key replicable parameters, creating a living, searchable, and expandable cultural database. This comprehensive digital repository directly drives practical application. In Dalishu Village, Dandong, the AIGC platform ingested local Manchu heritage data, extracting key motifs like "Momo Ren" and the symbolic proportions of the "Suolun Pole." Subsequently, it generated 20 distinct design proposals for porch details and window lattices. The community-selected final scheme incorporated stunning laser-cut steel grille screens directly inspired by the traditional paper-cutting patterns and porch columns echoing the exact proportions and symbolic presence of the Suolun Pole, significantly enhancing the cultural authenticity and visual identity of local homestays. Homestay owner Guan Guilan observed the immediate impact: "Tourists instantly recognize this as a distinctive Manchu home, not just another anonymous guesthouse. They ask questions, take photos, and want to learn the stories. Our occupancy rates surged by 70%, pushing annual income well past 200,000 yuan."

Furthermore, AIGC revolutionizes intergenerational knowledge transfer, making complex traditional crafts accessible. In Yanbian, Jilin, the traditional Korean Ondol heating system was transformed into an interactive intelligent thermal simulation model within a virtual reality environment. Young trainees used VR headsets to virtually practice laying flue channels, calculating thermal mass requirements, and understanding airflow dynamics in real-time. Master craftsman Jin Chenghuan noted the dramatic impact: "Traditional apprenticeships took years of patient

observation and practice, few young people today have that kind of time or patience. Within just one intensive month, over 20 motivated youth mastered the core techniques virtually before even touching a brick or trowel—a learning pace and engagement level we never imagined possible before." The fusion of AI-powered simulation and immersive technologies ensures the survival, accessibility, and evolution of critical construction crafts that were on the brink of vanishing forever.

3.2 Ecological Intelligence: Algorithmic Optimization for Extreme Climates

Leveraging vast environmental datasets and sophisticated physics-based simulations, AIGC significantly enhances building performance, occupant comfort, and energy resilience in the face of Northeast China's brutal climate. In Fulaerji Village, Heilongjiang, the AIGC platform ingested massive amounts of real-time and historical data from 120 regional weather stations, combined with detailed local soil thermal property maps. Employing advanced multi-objective genetic algorithms, it optimized numerous parameters simultaneously: building orientation to maximize precious winter solar gain while minimizing problematic summer overheating, determining the optimal window-to-wall ratio to perfectly balance essential daylighting with minimizing crippling heat loss, and precisely integrating parameters for wall, roof, and foundation material choices alongside scientifically calculated insulation thickness. The tangible result: local indoor temperatures now remain consistently stable at a comfortable 20°C ±1°C throughout the entire year. An AIGC-designed integrated ground-source heat pump system operates at roughly one-third the energy consumption of the old, inefficient coal stoves it replaced. Corresponding household heating expenses dropped by a remarkable 60%, freeing up significant income for other needs.

In Yongcheng Village, Jilin, AIGC proposed a clever "South-Low, North-High" massing strategy for a new cluster of homes. The low southern section maximizes penetration of valuable winter sunlight deep into the main living spaces, while the taller northern block acts as an effective barrier against the region's prevailing, biting cold winds. Triple-glazed argon-filled windows, equipped with automatic night insulation shutters that deploy at sunset, combined with a smart hybrid ventilation system (integrating heat recovery and natural stack effect principles), ensure uniform thermal comfort throughout the dwelling. Farmer feedback highlighted a crucial improvement: while floors were once icy cold and heated beds (Kang) uncomfortably hot in patches, every corner of the home now feels consistently dry and comfortably warm. Post-renovation energy monitoring showed a substantial 38% reduction in annual heating energy demand and a significant 25% decrease in average indoor relative humidity, drastically mitigating persistent problems with mold growth and condensation on walls and windows.

For effective renewable energy integration despite the harsh conditions, AIGC designed highly tailored solutions. A system implemented in a northern Liaoning village exemplifies this: Building-integrated photovoltaic (BIPV) panels, installed at the algorithmically determined optimal tilt on robust south-facing roofs, feed generated electricity into a resilient local DC microgrid. This microgrid connects intelligently to large-capacity LiFePO4 batteries for overnight storage and powers an efficient electric radiant floor heating system. This carefully orchestrated configuration enables reliable coverage of all household electricity and heating needs throughout the year, demonstrating concretely how AIGC ensures viable and reliable renewable integration even under the most demanding climatic constraints.

3.3 Demand Responsiveness: Precision Design for Real Life and Work

AIGC facilitates highly customized, functionally integrated designs that directly respond to specific user input and the practical realities of rural livelihoods. In Meilisi District, Heilongjiang, livestock farmer Liu adopted an AIGC co-designed "Front-Residence, Rear-Livestock" integrated dwelling module. The robust ground floor houses essential feed processing machinery and ample, organized storage. The upper level provides comfortable, well-insulated, and odor-isolated living quarters for the family. A connecting courtyard seamlessly integrates an anaerobic biogas digester that efficiently converts daily animal manure into usable cooking fuel and valuable organic fertilizer.Liu described the profound efficiency gains: "It's just a few steps from the warm bedroom

to the livestock shed for essential night checks during calving season. Manure removal is effortless—waste goes directly into the digester via a covered, hygienic chute. Sanitation is vastly improved, and we get free gas for cooking!" Detailed workflow analysis confirmed a 40% reduction in daily operational time spent on essential chores.

Addressing the critical issue of elderly safety in a pilot village in Panjin, Liaoning, AIGC-generated renovation designs incorporated thoughtful, technology-enhanced features: gently sloped smart ramps with embedded heating elements for non-slip surfaces even in icy conditions, height-adjustable ergonomic handrails positioned for optimal support, and bathrooms equipped with discreet fall-detection sensors and easily accessible emergency call buttons linked directly to family members' phones. Post-implementation tracking over a year showed a highly encouraging 60% reduction in reported fall-related incidents among residents aged 65 and over, significantly improving safety and independence for the elderly population.

4. The AIGC-Driven Design Framework: Data, Algorithms, and User Collaboration

4.1 Multidimensional Data Acquisition: Constructing the Digital Twin

The foundation for effective and meaningful AIGC application is rich, meticulously structured, and deeply contextually relevant data. In Hetu Ala Village, the process began with intensive terrestrial laser scanning and high-fidelity photogrammetry, creating millimeter-accurate 3D digital twins of extant traditional dwellings, capturing every crack and curve. Concurrently, experienced ethnographers conducted in-depth interviews, documenting oral histories detailing traditional construction rituals, specific spatial uses, and embedded cultural symbolism. Every weathered brick, intricate timber joint, and faded decorative motif was digitally captured and cataloged. The precise position and orientation of the sacred Suolun Pole relative to the main gate and the kitchen stove—a spatial syntax imbued with profound cultural meaning—were meticulously recorded. The resulting comprehensive cultural heritage database is vast: encompassing over 2,000 high-resolution photos of architectural details, more than 100 hours of carefully annotated video documenting vanishing construction techniques, rituals, and elder narratives, and over 500,000 words of transcribed oral histories and folklore directly related to dwellings and their role in community life.

For robust environmental performance optimization, the AIGC platform integrated continuous real-time telemetry from a dense network of 120 IoT-enabled weather stations strategically deployed across Heilongjiang, supplemented by decades of national meteorological archives. This massive data stream feeds into a sophisticated high-resolution (1km x 1km grid) climate model specifically calibrated for the unique conditions of Northeast China. Crucially, localized microclimate effects—such as wind funneling caused by inter-village hills, highly localized snow accumulation patterns around buildings, and hyperlocal solar exposure trajectories shifting dramatically across seasons—were actively simulated and continuously monitored. This unprecedented level of environmental granularity directly informed critical design decisions like optimal building orientation, strategic window placement for light and shelter, and the selection of appropriate, locally available external wall materials.

4.2 Algorithmic Innovation: The Engines of Intelligent Generation

The true power of AIGC lies in its specialized algorithms transforming raw data into actionable, intelligent design solutions[3]:Cultural Translation Algorithms (Transformer-based): Trained extensively on the curated heritage database, these sophisticated algorithms generate culturally authentic yet novel design variations. For the Dandong window lattice project, the algorithm rapidly produced 15 distinct, visually appealing schemes, all strictly adhering to traditional proportional rules and symbolic motifs while offering fresh interpretations. Designers could then interactively adjust key parameters via an intuitive graphical interface (using sliders, drop-down menus)—tweaking pattern density, line thickness, desired light transmittance, or material type (wood, steel, composite)—reducing the design time per viable variant from weeks of laborious hand-drawing to under 2 hours, representing a remarkable 90% efficiency gain.

Ecological Optimization Algorithms (Physics-Informed Machine Learning): Coupling powerful machine learning with established physics engines like EnergyPlus and Computational Fluid Dynamics (CFD), these algorithms simulate thousands upon thousands of possible building envelope combinations, evaluating thermal performance, structural integrity, and cost. In a Liaoning case, the optimal solution identified by AIGC utilized locally sourced, sustainable compressed straw bale insulation (300mm thick) combined with strategically placed Vacuum Insulation Panels (VIPs) for critical thermal bridge treatment, achieving an excellent overall U-value of 0.15 W/(m²·K). In the colder reaches of Heilongjiang, AIGC recommended innovative Phase Change Material (PCM)-infused walls combined with a specially adapted Air Source Heat Pump (ASHP) featuring geothermal pre-heating capability, successfully slashing peak heating load by an impressive 45% compared to conventional designs.

4.3 Iterative User Participation: Co-Creation and Feedback Loops

AIGC fosters continuous, meaningful collaboration, ensuring designs are grounded in the practical realities of daily life[4]:Immersive VR Co-Design: In Yanbian, farmer Park Jong-hyun donned a VR headset to physically "walk" through several AIGC-generated design options at a true 1:1 scale within a virtual replica of his property. Park provided crucial, experience-based feedback impossible to capture on paper: "The initial location you proposed for the kimchi workshop means strong summer fermentation smells would drift directly into the bedroom windows." Observing this potential issue vividly within the linked VR environment, designers immediately modified the virtual model, adding an automatic ventilation skylight above the workshop and repositioning the large fermentation vats further downwind—changes visible and testable by the farmer in real-time. Park emphasized the core principle: "The tech is impressive, truly, but the design only works perfectly if it fits seamlessly into our daily rhythms, our work patterns, and yes, even how our homes smell during different seasons."

BIM-Enabled Precision Construction: The crucial transition from AIGC design concepts to physical construction is meticulously managed via detailed Building Information Modeling (BIM). In Dalishu Village, the precise installation of a modern reinterpretation of the Suolun Pole—a central cultural element—was guided step-by-step by the BIM model, achieving final placement accuracy within a tight 2mm tolerance, ensuring both structural soundness and symbolic correctness. The lead contractor noted the significant advantage: "The BIM model provides us with millimeter-precise construction drawings and assembly sequences, almost like advanced LEGO instructions for complex buildings. We can visualize clashes and spot potential errors on the virtual site model long before they become costly mistakes on the actual job site."

Post-Occupancy Feedback Driving Algorithm Optimization: Operational performance data (energy use, temperature logs) and detailed user satisfaction surveys are systematically fed back into the AIGC platform. For instance, farmers in Fulaerji reported uncomfortable drafts in a covered poultry corridor connecting living quarters and livestock sheds. Sensor data subsequently confirmed localized cold spots. This valuable user experience directly prompted targeted algorithm updates, prioritizing enhanced corridor insulation and automatic draft curtains in all future designs generated for similar layouts. Crucially, each implemented project becomes a rich training dataset for the AI, each farmer's specific comment or suggestion helps fine-tune the underlying algorithms, allowing the entire AIGC system to progressively adapt and learn from local nuances and unforeseen needs, becoming ever more responsive and effective.

5. Empirical Case Studies and Future Outlook: From Pilot Breakthrough to Regional Empowerment

Case 1: The Revitalization Story of a Manchu Village in Liaoning
Before the Makeover: In a Liaoning village, 32 traditional "Pocket House" dwellings were on the verge of abandonment. Over 60% of the young people had migrated to cities, the average indoor temperature in winter dropped below 15°C, and the sense of community belonging was fading.What AIGC Did: Village officials, with the help of AIGC technology, digitized the intricate "Momo Ren"

paper-cut patterns and used laser cutting to engrave them on outdoor privacy screens and indoor partitions, combining aesthetics with practicality. They reintroduced the symbolic "Suolun Pole" as structural porch columns, blending traditional meaning with architectural function. Villagers designed a foldable kang table that serves as a dining space by day and a communal craft table by night. They reorganized the courtyard to make room for traditional Manchu games and community events. In Aunt Wang's house, they insulated the walls with 400mm-thick straw bales and special materials at the corners, and installed a 6kW BIPV (Building-Integrated Photovoltaics) roof system for both beauty and power generation.18 Months Later: The village achieved nearly complete energy self-sufficiency, generating 3,500 kWh of net electricity annually. During the May Day holiday alone, it received over 5,000 tourists. Homestay prices rose from 80 RMB to 280 RMB per night, reflecting the premium of cultural experiences. Each household earned an extra 18,000 RMB annually, and more than 20 young people returned to learn "Momo Ren" paper-cutting. The Suolun Pole became a living cultural symbol, integrated into rituals and storytelling.

Case 2: The Turnaround of a Korean Kimchi Village in Yanbian, Jilin

The Old Problems: In a Yanbian village, seasonal kimchi production was carried out in unhygienic open yards, yielding only about 10 tons annually. Untreated wastewater polluted local streams, and young people showed no interest in the traditional craft.AIGC-Driven Solutions: With AIGC assistance, villagers adopted a "south-low, north-high" layout for buildings, maximizing winter sunlight for homes while shading temperature-sensitive production areas. They developed an IoT-controlled modern Ondol (floor heating) system to recycle waste heat from kimchi fermentation vats. The ground floor was transformed into a bright, hygienic workshop with stainless steel vats, pH/temperature sensors, and a dedicated livestream studio for e-commerce. They built a community anaerobic digester to convert kimchi wastewater into biogas for cooking and liquid fertilizer.The Results: Annual kimchi output surged to 50 tons, and livestream sales reached 1.2 million RMB. Participating families saw a per capita income increase of 25,000 RMB. Three families used profits to buy refrigerated trucks for wider market reach. Eight young adults returned as full-time "livestream entrepreneurs," promoting their families' products.

Case 3: A New Chapter for a Daur Farming-Pastoral Village in Heilongjiang

Past Challenges: In a Heilongjiang village, living quarters, livestock barns, and greenhouses were far apart, making winter travel dangerous (avg. -20°C). Open manure piles caused odor and pollution, and traditional architecture was ignored.AIGC-Enabled Upgrades: A villager named Xiao Li revived the traditional "Qikami" boot-shaped double-door airlock to keep cold air out and built an enclosed insulated corridor connecting homes, barns, and greenhouses. He installed a hybrid heating system with an air-source heat pump and phase-change material walls for stable temperatures. The village established a zero-waste cycle: manure → biogas (for cooking/heating) → organic fertilizer. Public pavilions adopted the traditional "Xieren Zhu" structure, with Daur fur patterns on interior textiles.The Impacts: Daily commute time for chores reduced by 30%. All organic waste was processed on-site, eliminating pollution. Respiratory issues among elderly villagers dropped by 70%. The project became a provincial demonstration site, sparking youth interest in Daur hunting-gathering culture and driving cultural tourism initiatives.

6. Conclusion

As mature, sophisticated AIGC algorithms progressively decode the intricate cultural DNA embedded within the architectural heritage of the black soil region[5]., Northeast China's rural housing is undergoing a profound and necessary metamorphosis. It is transitioning from being mere derivative copies of urban anonymity—structures often ill-suited to their environment and community—into vibrant, responsive living organisms. These revitalized dwellings are actively safeguarding irreplaceable heritage, dynamically adapting to the relentless challenges of extreme climates, and continuously evolving in intelligent response to the changing lives and livelihoods of their inhabitants. The ultimate success of this technological revolution, however, fundamentally hinges on preserving rural autonomy and agency throughout the process. AIGC must be thoughtfully employed as a powerful catalyst for activating and creatively reinterpreting cultural

DNA to meet contemporary needs and aspirations, not as a blunt instrument to supplant or erase precious tradition. Digital tools should be harnessed to empower endogenous rural vitality, fostering innovation that is deeply rooted in local identity and practical wisdom, rather than imposing external, homogenized urban templates that disregard context.

The "Data-Intelligence-User" tripartite framework demonstrated robustly in this study provides a solid methodological scaffold for achieving this balance. By rigorously anchoring AIGC applications in profound cultural understanding, sound environmental science, and genuine participatory collaboration, villages across Northeast China can robustly sustain their unique cultural roots while confidently navigating the powerful tide of technological advancement. This integrated approach charts a viable and inspiring path towards a revitalization characterized by the poetic ideal of "seeing the mountains, seeing the waters, remembering the nostalgia" (Wangdejian Shan, Kandejian Shui, Jidezhu Xiangchou)—a future where ecological harmony, cultural continuity, and meaningful technological progress are seamlessly interwoven within the fabric of rural life. The practical lessons learned and the innovative paradigm forged here in the Northeast offer not only a vital regional solution but also present a compelling and adaptable "Northeast Model" (Dongbei Fang'an). This model holds significant promise for realizing sustainable, culturally rich, and technologically empowered rural futures across the diverse landscapes of China and globally in our increasingly digital age. The journey from pilot success to widespread, equitable empowerment continues, demanding continued collaboration, ethical application, and a deep respect for the places and people at its heart.

References

[1] Li Peiyuan, Liu Yonggang. "Analysis of the Current Situation and Development Trends of Environmental Art Design for Rural Housing in Liaoning Province". Journal of Liaoning Communication University, 2022, 39(8): 1-12.

[2] Ministry of Housing and Urban-Rural Development (MOHURD). *Design Standard for Energy Efficiency of Residential Buildings in Severe Cold Zones: JGJ 26-2018*. Beijing: China Architecture & Building Press, 2018.

[3] Li Baofeng, Zhang Wei, Kim Y. "Digital Translation of Vernacular Architecture—Innovative Design of Traditional Dwellings Based on AIGC". Architectural Journal, 2024, 65(5): 45-53.

[4] State Council. Guiding Opinions on Promoting the Revitalization of Rural Industries. State Council Document No. 12 [2019], 2019.

[5] Research Group on Protection and Development of Traditional Dwellings in Northeast China. Research Report on the Current Situation of Ethnic Minority Dwellings in Northeast China. Shenyang: Shenyang Jianzhu University Press, 2022. (Primary source of baseline data)