



Theoretical Framework and Practical Pathways for AI Empowered Campus Environment Optimization Design in Private Schools

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Abstract. Campus environments at private schools tend toward formulaic design where aesthetics stay uniform and decisions lean on experience rather than data. This paper proposes a three layer model of perception, diagnosis, and decision, validated through fieldwork at Kunming Vocational University of Science and Technology. The perception layer feeds street view images into a semantic segmentation model to extract quantifiable landscape indicators, supplemented by behavioral data from existing campus systems. The diagnosis layer scores sites along four dimensions: green coverage rate, spatial morphology, cultural visibility, and functional facilities. The decision layer converts scores into concrete renovation proposals through rule matching and generative design. Case validation shows the framework operates under typical private institution resource constraints, moving landscape optimization from experiential judgment toward data driven decision making.

Keywords: Artificial Intelligence; Campus Environment Optimization Design; Semantic Segmentation; Landscape Design; Smart Campus

1 Introduction

Private higher education in China expanded rapidly over the past decade. Campus construction at these institutions lagged well behind public universities in design quality and investment. Tighter budgets. Shorter timelines. A near absence of professional landscape firms willing to work within the cost ranges private colleges absorb. Across dozens of new private campuses in southwest China, the result is the same "lawn, axis, plaza" formula with little adjustment for local climate, culture, or usage patterns.

A campus is a self contained urban unit with defined boundaries and measurable movement patterns. Street view imagery offers a low cost approach to visual condition capture at scale. Nearly all published applications concentrate on well funded public universities or Western contexts. Whether the same pipeline applies to a budget constrained private vocational college in Kunming remains unanswered.

This paper addresses three questions using Kunming Vocational University of Science and Technology as a case site. Can street view semantic segmentation reliably capture landscape conditions in small, heterogeneous campuses? Can the resulting indicators feed an assessment system pointing to specific design interventions rather than generic recommendations? Can Bai ethnic architectural traditions be translated into landscape features through reproducible technical means?

2 Related Work

2.1 Theoretical Foundations of Built Environment and User Wellbeing

Physical environments shape psychological states. Wilson proposed the biophilia hypothesis, arguing humans possess an innate affinity for natural environments ^[1]. Kaplan and Kaplan developed attention restoration theory, distinguishing between the "hard" attention demanded by urban stimuli and the "soft" attention elicited by vegetation and water ^[2]. Ulrich measured reduced blood pressure and eased muscle tension after subjects viewed natural versus urban scenes ^[3]. These studies justify campus landscape design from a behavioral science standpoint but stop short of telling a designer where trees should go or what spatial proportions feel right.

2.2 AI Applications in Built Environment Assessment

Deep learning changed what can be measured from a single photograph. Chen et al. proposed DeepLabV3+, pushing pixel level segmentation accuracy to the point where indicators like green view rate, sky visibility, and facade continuity could be computed automatically across thousands of images [4]. A keyword co occurrence analysis of street view image research in CNKI shows deep learning and semantic segmentation now dominate the methodological discussion (Figure 1). Lee et al. noted that precise segmentation serves as both the foundation for fine grained indicator computation and a link making qualitative landscape evaluation more interpretable [5].

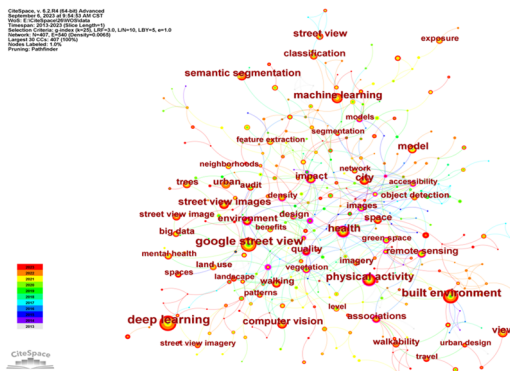


Fig. 1. Keyword co occurrence map of street view image research in CNKI. Source: Compiled by the authors.

Chis et al. combined BIM with biophilic design, using neural networks to predict relationships between design elements and perceived indoor quality, achieving R squared of 0.91 [6]. Yang et al. applied DeepLabV3+ to segment street view imagery, extracting quantitative indicators of street greening structure and visual perception characteristics across Chinese urban districts [7]. Xu et al. employed field photographs and large language models to track seasonal landscape changes, finding vegetation contributions to visual quality varied significantly across seasons [8].

2.3 Gaps in Existing Research

Three gaps stand out: research subjects skew toward public institutions and Western universities; most studies stop at evaluation without generating actionable design strategies; regional cultural integration remains qualitative with no computable workflow. The framework below addresses all three.

3 Theoretical Framework: A Three Layer Perception Diagnosis Decision Model

3.1 Overall Logic

Campus landscape is a living system of vegetation, infrastructure, and human activity. The three layer model reorganizes the design process into sequential computational stages. The perception layer converts physical conditions into numerical indicators. The diagnosis layer interprets those against design criteria. The decision layer translates interpretations into intervention proposals. Anomalous patterns detected during diagnosis may prompt denser imagery capture.

3.2 Perception Layer: Landscape Recognition from Street View Imagery

Cost is the overriding concern. At key campus nodes, 360 degree images are captured by vehicle mounted panoramic cameras. Main roads are sampled at roughly 50 meter intervals with denser coverage at cultural plazas. DeepLabV3+ classifies each image into vegetation, sky, facade, road, and infrastructure, yielding standard indicators: green view rate, sky openness, and facade continuity.

Behavioral data enters through channels already operating within campus IT infrastructure. Gate access card records capture spatial traffic at building entrances with second level precision and roughly 3,000 person times per day, already deployed at zero additional cost. Library check in records track learning space usage at floor entrances with minute level precision and approximately 800 person times daily. Mapping these data to temporal windows and spatial zones overlays usage intensity onto visual indicators.

The behavioral data collection scheme is summarized in Table 1. Behavioral patterns diverge across functional zones. The teaching area draws roughly 1,500 people daily in

a tidal pattern between 8:00 to 8:30 and 12:00 to 12:30, with green view rate and spatial morphology as priority diagnostic indicators. The dormitory area handles approximately 2,000 person times with dense morning and evening peaks between 7:00 to 8:00 and 21:00 to 22:00, where functional facilities and greening quality matter most. The landscape courtyard sees only about 300 visits daily, making cultural visibility the relevant diagnostic dimension. The library sustains roughly 800 person times with day-time concentration between 9:00 to 11:00 and 14:00 to 17:00, requiring attention to spatial morphology and facility provision. All data comes from aggregated statistics in the routine management system. No individual identification is involved.

Table 1. Behavioral Data Collection Methods3.3. Diagnosis Layer: Four Dimensional Quality Evaluation

Data Dimension	Collection Method	Data Source	Temporal Granularity	Spatial Granularity	Sample Magnitude	Justification
Spatial traffic flow	Gate access card records	Campus smart card system	Second level	Building entrances	~3,000 person times/day	Already deployed in private institutions, zero additional cost
Learning space usage	Library check in records	Library management system	Minute level	Floor entrances	~800 person times/day	Reflects learning behavior distribution

This table focuses on zero cost data channels already available at private institutions, underscoring the framework's feasibility advantage in resource constrained settings.Green view rate considers total vegetation coverage, spatial uniformity, and seasonal variation. Spatial morphology examines visual permeability, enclosure ratios, and building height to open space proportions. Cultural expression measures how visible regional symbols are on the ground. Functional facilities assess whether seating, shade, lighting, and wayfinding are distributed where usage demand is highest.

4

Design Strategy Generation and Practical Pathways:

Kunming Vocational University of Science and Technology Case

4.1

Case Selection Rationale

Kunming Vocational University of Science and Technology holds Ministry of Education "AI College" pilot status and is designated as an informatization benchmark for vocational education in Yunnan Province. Its School of Architecture and Civil Engineering houses the "Yunnan Ethnic Traditional Village Building Cultural Heritage Innovation Center," which has completed digital documentation of Bai ethnic "Three Rooms and One Screen Wall" vernacular dwellings. Digital campus infrastructure supports the data pipeline, and ethnoarchitectural research materials are available for cultural integration design.

4.2 Perception Layer Implementation

Teaching zones, residential clusters, landscape nodes, and circulation routes each received dedicated sampling points at roughly 50 meter intervals with denser coverage at cultural plazas.

Segmentation ran through DeepLabV3+ fine tuned on campus imagery. Output categories included vegetation, buildings, pavement, landscape features, and cultural installations. Metrics extracted per point: green view rate, sky ratio, facade ratio, cultural facility visibility. Validation against manual annotation confirmed accuracy.

4.3 Diagnosis Layer Implementation

Green view rate analysis generated contour maps making vegetation deficiency zones visible. Teaching building clusters sit on large hardscape expanses with almost no canopy. These are where students walk most densely between classes, and where shade is scarcest.

Sky openness and facade height to width ratio were computed at each point. Areas scoring high on sky openness present opportunities where vertical greening can raise green view rate without sacrificing permeability.

For cultural expression, the School maintains digital image archives of Bai ethnic screen wall facades and field photography from Dali Ancient Town as source material for motif extraction. Bai cultural elements are structured along three coding dimensions. Screen wall geometry, captured through height width ratio, eave curvature, and segmentation ratio from the digital archive, translates into paving pattern variants. Decorative motifs, coded for symmetry, repetition period, and hierarchical structure from field photography, inform structural features of landscape elements. Spatial organization logic, parameterized through enclosure ratio, axial symmetry, and sequence hierarchy from architectural typology literature, guides landscape node layout. Some parameters yield to direct measurement; others require scholarly interpretation. This coding pathway resonates with the parametric HBIM method for Bai traditional dwellings proposed by Mao et al., who verified the feasibility of parameterizing Bai architectural elements from a structural building information modeling perspective [9].

The specific coding scheme appears in Table 2. Functional facilities assessment overlaid segmentation with survey data, flagging points where seating, lighting, or signage fell below usage demand.

Table 2. Bai Architectural Cultural Elements Coding

Cultural Element	Source Material	Coding Parameters	Design Direction	Translation
Screen wall geometry	Digital image archive	Height width ratio, eave curvature, segmentation ratio	Paving variants	pattern

Decorative motifs	Field photography	Symmetry, repetition period, hierarchical structure	Structural features of landscape elements
Spatial organization logic	Architectural typology literature	Enclosure ratio, axial symmetry, sequence hierarchy	Landscape node layout

4.4 Design Strategy Formation Mechanism

Strategies follow a diagnosis, match, optimize sequence. Low green view rate nodes trigger vertical greening with seating proposals. Zero cultural density zones trigger supplementary cultural landscape nodes. An image generation model converts data and strategy into visual proposals for team review. AI produces options. Humans make the final call.

The pipeline uses Stable Diffusion v1.5 with ControlNet v1.1 in segmentation mode, receiving semantic maps from the perception layer as spatial constraints. Sampling runs at 30 steps, CFG scale 7.5, on an RTX 3060 with 12GB memory, using weights from Hugging Face. Choosing v1.5 over newer versions was deliberate: the ControlNet ecosystem is more mature, community prompts are richer, both helping other researchers reproduce results. Modest hardware specifications demonstrate that the generative layer does not require expensive infrastructure, which matters for resource constrained institutions.

Bai screen wall geometry abstracts into paving pattern variants. Parametric tools transform ethnic textile patterns into structural features of landscape elements: seat backs, corridor nodes, flower bed edges.

4.5 Implementation Safeguards and Practical Pathways

A digital campus platform handles data storage and visualization. The AI Collaborative Innovation Center supplies computing power. The "One Hall, Two Zones" training base provides physical space for element extraction and model fabrication.

Scaling follows pilot first, expand later. The School of Architecture completes workflow validation first. Campus wide rollout follows, with user feedback feeding a diagnosis, design, implementation, re diagnosis cycle.

4.6 Framework Generalizability

The perception, diagnosis, decision sequence applies beyond campuses. Traditional towns, historic villages, and municipal public spaces face analogous problems of measuring conditions, diagnosing deficiencies, and generating proposals. Data sources and criteria will differ.

5 Conclusion

This paper addressed the lack of systematic data support in campus landscape design at private vocational colleges by constructing and testing a perception, diagnosis, decision framework at Kunming Vocational University of Science and Technology. The perception layer converts physical conditions into computable indicators via street view segmentation. The diagnosis layer evaluates four dimensions: greening, spatial form, cultural representation, and functional facilities. The decision layer outputs strategies through rule matching and generative design. Validation shows the framework operates under real private institution constraints.

Limitations require acknowledgment. The project spans one year (2025 to 2026) with RMB 2,000 funding (approximately USD 280), making it a proof of concept without external replication. The case institution lacks environmental sensor networks and high performance computing. Cross cultural applicability of the underlying theories requires further testing. These limitations do not negate internal logical consistency but require caution about generalization. Future directions include cross site validation at institutions with different conditions (2026 to 2027), longitudinal data across seasonal cycles, and IoT sensor integration for real time perception.

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