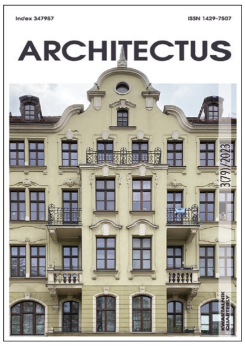

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Building a dataset of Wrocław's historic tenements. Image annotation for machine learning applications

Abstract

In recent years, the development of artificial intelligence (AI) has introduced new possibilities in the field of architecture. In the realm of compositional analysis and recognition of architectural details, AI can have a significant impact, supporting historical-architectural research, the valorisation of historic buildings, and design in accordance with historical context. However, the successful use of AI in analysing architectural objects requires large datasets to train and test the models. The article aims to demonstrate the creation of a new dataset containing annotated images. The *NeoFaçade* collection serves as a historical dataset, containing façades of the 19th and 20th century townhouses from Wrocław and, in due course, other cities with similar architectural styles (for example, Szczecin or Berlin). Gathering high-quality photographic material and marking architectural elements accurately, enables to use the dataset for various AI tasks: semantic segmentation, image classification, and generation of pictures of tenement house façades. This way, the *NeoFaçade* dataset can potentially be applied in architectural practice or historic preservation.

The methodology for creating the dataset developed by the authors consists of three stages: preparation of the data acquisition procedure, data processing: creation of a dataset that meets the requirements and a summary of the dataset. All stages are discussed in detail in the paper, including an example annotation of one of the townhouses.

In the future, the research team will focus on expanding the collection with new photographs, while also striving to demonstrate *NeoFaçade* value as a tool supporting innovative research projects and practical applications.

Key words: dataset, façade, townhouses, historic architecture, machine learning

Introduction

In recent years, the volume of collected data has increased exponentially. This data boom is not just a general trend but also a growing reality in the field of architecture. Data is now the foundation for innovative design solutions, trend analysis, and space optimization. Architects leverage data from various domains to create more efficient and sustainable designs (Bölek et al. 2023).

Spatial data, which encompasses information about location, topography, urban infrastructure, climatic conditions, and other factors, can be employed for urban planning, the analysis of construction areas, or the assessment of the impact of the environment on architectural designs. Building use data may include information on energy consumption, space utilization, human mobility patterns, and comfortable living conditions. The analysis of such data

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can facilitate the design of more effective, functional, and user-friendly buildings. Historical, demographic, and social data can also be beneficial for architects in understanding the cultural and social context of the area under consideration. They consider local needs and community preferences, thereby contributing to more appropriate designs. Data on space use patterns are increasingly collected, such as data on pedestrian traffic, the use of public spaces, and local customs. The analysis of this data can lead to the optimization of urban and architectural designs. Datasets containing information about trends in architectural design, interior design, and space use can be used to identify new inspirations, styles, and directions for development in architecture. Automating image classification in cultural heritage through deep learning, particularly convolutional neural networks, improves accuracy but requires large, well-prepared datasets. Creating and sharing new datasets is crucial for maximizing AI's benefits in this field (Llamas et al. 2017). Segmentation is vital in urban planning, especially for analysing building façades. City digital twins (CDTs) allow the creation of high-quality synthetic datasets, improving segmentation efficiency compared to virtual data (Zhang et al. 2022). Parametric BIM aids in generating training data for AI to recognize building objects in images, demonstrating that AI trained on synthetic data can effectively solve real-world architectural problems (Alawadhi, Yan 2023). Generative AI significantly enhances innovation and efficiency in architectural design, from creating 2D images and 3D models to influencing all design stages (Li et al. 2024).

Integrating data and artificial intelligence technologies in architectural design represents a game-changing shift in the field. It paves the way for innovative designs that are more community-centric, efficient, and sustainable. The availability of comprehensive datasets has become a crucial tool for architects, empowering them to create future-proof construction and urban planning solutions.

Constructing datasets has many vital purposes and benefits in the field of machine learning and data science, as they are the foundation for training machine learning models. The larger and more representative the dataset, the better results can be achieved. Datasets allow the collection of information about a given area, which can lead to the detection of essential patterns, trends, or other relationships in the data. It is essential that datasets are tailored to specific problems and contexts, as this allows the creation of more effective and accurate models for solving particular tasks (Bialek et al. 2016; Vaccari et al. 2020).

The utilization of publicly available datasets, commonly referred to as benchmark datasets, is of utmost significance in the evaluation of model performance. The implementation of trusted procedures and datasets instils a sense of reliability and objectivity within the evaluation process, thereby allowing relatively objective comparisons, which in turn enhances the credibility of our evaluations. Thanks to this, we can improve existing solutions and create new, more advanced technologies with confidence.

Overall, constructing datasets is a crucial step in machine learning and data analysis that enables the development of new models, techniques and tools and leads to the discovery of new patterns, relationships, and trends in data. The increasing prevalence of artificial intelligence in the field of architecture necessitates the construction of novel, expansive, and structured datasets. AI models that require knowledge of specific architectural styles are dependent upon the availability of uniform datasets.

The following article serves as an introduction to a new dataset, collected and created by the authors. The collection serves the purpose of a historical dataset, containing façades of tenements from the 19th and early 20th centuries from Wrocław and, in due course, from other cities of similar architectural styles (for example Berlin and Szczecin).

The paper is structured as follows: sections describe the methodology for creating the dataset, verification of annotations and present example of annotated façade from the collection. The summary concludes the paper.

Methods

Datasets represent the fundamental building blocks of machine learning development. Standardized benchmark datasets have come to be accepted as a reliable tool for the comparison and evaluation of various models (Kistowski et al. 2015). The quality of datasets can be described by five attributes: relevance, reproducibility, fairness, verifiability and usability.

In consideration of the aforementioned key characteristics of the dataset, the authors have developed a methodology for the creation of the collection (Kistowski et al. 2015). Our methodology consists of eight steps divided into three stages:

– Stage I. Preparation of the data acquisition procedure (objectives formulation, use case requirements determination, planning the procedure of gathering images, collecting photos taken by a group of collaborating students).

– Stage II. Data processing: creation of a dataset that meets the requirements (photographs review in consideration of their quality, photos annotation, verification of annotations).

– Stage III. Summary of the dataset (reconciliation of descriptions, the description of the generated dataset, and its transfer for use in the machine learning models).

Stage I.
Preparation of the data acquisition procedure

Providing large datasets to train and test models is necessary for achieving success in AI learning. However, the initial sets cannot be too diverse because there will be too little data for a given style or type of element. The model cannot learn its features and may even treat it as "noise". At the same time, the dataset must be varied because otherwise, the model will be overfitting and unable to cope with new examples. That is why we chose one city to start with so that the tenement houses would be manageable.

Objectives formulation

The objective is to create a collection of photographs depicting the of historic townhouses in Wrocław dating from the 19th and early 20th centuries. These buildings serve as historical heritage of the city, representing a variety of architectural styles, emphasizing the importance of creating a historical dataset. Furthermore, the development of a large and structured dataset represents a crucial aspect of the expanding field of artificial intelligence.

As previously mentioned, the dataset will be expanded to include photographs of tenement houses from other cities, namely Berlin and Szczecin. These areas exemplify analogous architectural styles to Wrocław, as illustrated in Figure 1. The selection of examples is influenced by the prominence of the capital, Berlin, which serves as a model for the other two. The architectural resemblances are essential due to the substantial volume of data required for artificial intelligence to acquire knowledge.

An important aspect to consider is the balance of the dataset. It is essential to maintain the homogeneity of the collection by limiting the scope to a particular type of tenements, while at the same time including different architectural styles. This allows the relevance of the dataset to be maintained, so that its behaviour correlates with the desired results (Kistowski et al. 2015).

Use case requirements determination

As previously stated, the construction of large datasets represents the fundamental basis for the training of machine learning models. Consequently, the development of a historical tenements collection could prove to be a highly valuable resource. One potential application of such a dataset is semantic segmentation, which is the process of detecting and identifying elements found in photographs of historical façades, such as doors, windows, or architectural details. The task can be expanded to identify the compositional features and styles of façades.

In the long term, artificial intelligence could be employed to generate façade concepts based on historical backgrounds, preset conservation guidelines, designers' assumptions, or legal regulations. Moreover, this training dataset would facilitate the analysis and valorisation of historic architectural elements. The information gathered could also lay the groundwork for developing a pattern book of historical details, serving as a valuable resource for architectural researchers and designers alike.

Planning the procedure of gathering images

It was recommended that as many people as possible be involved in the creation of the Wrocław tenements façades photo collection. Given the subject's particular characteristics, we evaluated that the selected 70 students of the Faculty of Architecture at the Wrocław University of Science and Technology would be the optimal team for creating the Wrocław tenements façades photo collection. The size of the group enabled the creation of a dataset containing examples from various neighbourhoods in a shorter time than would have been possible if a smaller number of photographers had been selected. Each participant was required to take photographs of the façades of 15–17 tenements, with a minimum of 3 images per façade. These images were to include one photograph taken from the front, 1–2 photographs taken from an angle or from the side and 1–3 photographs featuring one or more architectural details.

Fig. 1. Examples of tenement houses from selected cities:
a) Wrocław (photo by A. Marcinów), b) Berlin (photo by A. Pałka),
c) Szczecin (photo by M. Biegańska)

Il. 1. Przykłady elewacji z wybranych miast:
a) Wrocław (fot. A. Marcinów), b) Berlin (fot. A. Pałka),
c) Szczecin (fot. M. Biegańska)

Photographs could be taken with either a digital camera or a DSLR, although the use of a mobile phone was also permitted. In order to avoid the use of unnecessary perspective shortcuts and mage distortions, it was recommended that photographs be taken from the maximum possible distance from the front of tenements and at a right angle to the façade. Some shortcuts were unavoidable due to the location of the building in the dense city centre. However, it was forbidden to take photos with a cut-off portion of the façade in order to straighten one of the edges or to use filters and manual distortion settings during the photo-taking stage.

Photographs were to be taken during the day, with the precise timing contingent upon the prevailing lightning conditions, which could be influenced by the meteorological factors and the location of the tenement. It was recommended that the photographs were taken in cloudy weather, without harsh sunlight or precipitation, as this would afford the most optimal lighting conditions. It was of utmost importance not to take photographs in direct sunlight or after sunset, as this would result in a significant decrease in the quality of such photographs and their overexposure or underexposure.

In the event that undesirable, yet impossible to remove elements were present in the frame (e.g., greenery, tram traction lines, satellite antennas, parked vehicles), the photo was to be taken in accordance with the previously outlined instruction, with the aforementioned elements excluded, if possible. If moving objects or people appeared within the frame, it was recommended to wait until they leave the frame. However, if this was not possible, images containing a person's image or sensitive data would undergo an additional procedure during the further selection process due to the requirements of General Data Protection Regulation (GDPR), with the protected elements being marked as noise. This would ensure the anonymity of third parties in the baseline images.

Collecting photos taken by a group of collaborating students

In the process of creating the collection of Wrocław tenements façades photos, 1148 distinct façades fronts were photographed. The total number of photographs was about four times larger, as it included the photographs taken from the sides and the photographs of details. In this project, only the photographs of the façades were used, and they serve as the foundation of the dataset. The most representative images of the façades were named according to their addresses and followed the naming scheme district_street_number, for example: stare_miasto_ofiar_oswiecimskich_15 or olbin_ukryta_17. The images were organized into folders with analogous names and were then subsequently divided into two subsets: the first containing images suitable for annotation, and the second containing images that have been rejected. The supplementary photographs were also incorporated into the folders assigned to the tenements addresses, with a view to use them as additional material in the subsequent stages of the process.

Stage II.
Data processing: creating a dataset that meets the requirements (review photos – considering their quality, photos annotation, verification of annotations)

Review photos, considering their quality

Before proceeding with annotation, a review and selection of the photographs in the collection were conducted. The suitability of the images was assessed according to three criteria: aesthetic quality, originality of the façade, and compliance with the guidelines in stage 3. These guidelines stipulated that the tenements captured in the photographic material should:

– Be of good quality, with a high resolution and sharpness, as well as clarity, particularly in the case of architectural details, even at greater distances. The quality should be maintained regardless of the device used to take the photo. The minimum required image size was the 512 × 1024 pixels.

– Not be cropped and exhibit minimal distortions resulting from perspective shortcuts or camera construction. In the event that such distortions could not be avoided, it was essential the there be a means of secondary perspective correction. Façades exhibiting severe distortions were rejected.

– Be illuminated naturally by diffused light. The photographs should not be overexposed or dark. Images with flare and blur effects were rejected.

– Not be obscured by any additional elements, such as satellite antennas or traction lines, particularly in the front of the façade. In instances where this was not possible, the images with the least amount of such elements have been selected.

Consequently, images that were blurry, unclear, or pixelated were rejected, as well as overexposed or very dark pictures. Accepted images were those that did not exhibit significant distortion or cutting of the façade itself, with minimal noise and obscuring elements. Figure 2 illustrates examples of accepted and rejected photos[1].

Out of the 1148 photos taken for annotation purposes, approximately 600 met the criteria for the photographs' quality described above. From this pool of images, 400 were selected as the most representative and diverse tenements. The majority of images were rejected due to distortions and a large number of obscuring elements. Among the selected images, there were instances where the façades exhibited noise or perspective shortcuts. However, this was unavoidable, and through the selection process, façades where these irregularities could be easily corrected or removed were chosen.

Photos annotation

Annotation is the structured process of labelling elements in a dataset, employing labels or tags that categorize each object and provide additional information about it (Theodosiou, Tsapatsoulis 2020). The form of annotation may vary, e.g., to include numerical values or symbols, and may be expanded in accordance with the specific needs and objectives of the user. It is of the utmost importance that regardless of the format in which the data is presented, the inputs are uniform in terms of annotation. This entails the adoption of a unified method of annotation for all elements that are to be present in the dataset, regardless of when the labels were created.

Given the aforementioned prerequisites, it was deemed appropriate to utilize an RGB-based annotation system. This system allows for the description of the annotated

[1] The Authors of these photos do not want to reveal their names.

Fig. 2. Examples of accepted and rejected photographs:
a, b) accepted photographs (photo by M. Lewoniuk, M. Litwin), c, d) rejected photographs

Il. 2. Przykłady zdjęć zaakceptowanych oraz odrzuconych:
a, b) zdjęcia zaakceptowane (fot. M. Lewoniuk, M. Litwin), c, d) zdjęcia odrzucone

element in terms of its colour components (red, green, blue), which translates into a three-element entry, e.g., (0.255, 255). The recording of information in the form of three numbers constitutes a coherent description of the element, while simultaneously allowing for the analysis of each parameter independently.

The system developed for the annotation of a dataset consisting of photographs of tenements façades classified the elements according to three aspects: element, type and style, which were then encoded in numerical form (Table 1).

In the initial phase of the annotation, the fundamental components were identified without any consideration

Table 1. Fragment of the annotation legend (elaborated by authors)
Tabela 1. Fragment legendy anotacji (oprac. autorzy)

Element	R code	Type	G code	Style	B code
Door	110	semicircular arch	31	Art Nouveau	70
		curtain	32	Modernism	80
		other – difficult to determine	33	secondary, disruptive element	90

for their specific characteristics, such as windows, doors, walls, cornices, or pediments. This aspect is represented by the R component of the RGB code. Subsequently, the type, shape, material or distinctive features of the elements were analysed, for example, the window is rectangular, the wall is brick, and the pediment is triangular. These data were encoded as the G component. Finally, the style in which the tenement was built was included as the B parameter. The full legend, which encompasses all elements that have been included in the annotation along with their features and styles in enclosed in the Table 2.

A three-parameter coding system was identified as the most appropriate choice due to the multitude of elements, their diversity, and the necessity to analyse each aspect individually with freedom. The method allows for the straightforward storage of each parameter of the elements described and provides comprehensible notation for computer systems. For instance, an element described as a "Baroque Revival triangular pediment" could be translated into a simple numerical notation (230, 191, 50).

A total of 13 students of the Faculty of Architecture at Wrocław University of Science and Technology participated in the annotation of the 400 selected images. The students were selected on the basis of their availability and their ability to operate one of the graphic programs that allowed for the annotation (e.g., Photoshop, Krita, Corel). In order to verify the ongoing annotations, a chief content supervisor was selected. The expert responsible for checking the annotation files on an ongoing basis and consulting with students their content knowledge of the elements and their features.

In order to guarantee the accuracy and efficacy of the annotation process, it was essential to establish a uniform methodology for its implementation. To this end, an instruction manual was developed, which set out guidelines for the handling of the photographs and the annotation itself. The instructions included guidance on the processing of raw photographs, the utilisation of layers, tools and annotation shapes, and the exportation of annotated images. The annotators were permitted to utilize any graphic software program as long as it permitted the export of images in PSD format. At this project stage, flexible layer management and precise annotation were crucial. Annotators used the PSD format for efficient work and file sharing. While the final dataset will be available in more accessible formats such as TIFF or PNG, PSD was essential for its robust layer editing capabilities during annotation.

Firstly, the annotators were to rectify photographs exhibiting perspective shortcuts. While this was not always necessary, it was the initial step that should be undertaken before annotation, as it was considered as a fundamental aspect of the process.

The annotation itself was to be carried out in the subsequent step and involved marking the area of the façade on the additional layers available in the selected graphic software. The process of annotation is described in detail below with an example tenement from the dataset, illustrated in Figure 3.

The tenement in question is a historical neo-renaissance building with Art Deco elements. It is situated in the city centre on a broad street, which allowed to take the photographs in front of the building. The congestion at this particular location presented an obstacle to photography; however, the Author was able to take a photograph without any vehicles obstructing the view. It is worth noting that the image contains a minimal number of elements which could be considered noise. This section of the street is devoid of trees, lamps, and street signs. The only other obstruction to the view is a set of cables that are visible at the third-floor window level. Furthermore, the lighting and quality of the photograph were verified and approved.

The subsequent step involved the annotation of all elements present on the façade in accordance with the provided legend (Table 2). In order to simplify the markings, all objects regardless of their shape were marked with polygons. In the illustration of the annotation, the pilasters and columns exhibit a similar colour, yet not an identical one. They were both classified as vertical elements and have the same value of the R channel, yet they are distinguished as two different elements by the value in the G channel. Despite the differences being imperceptible to the human eye, the elements can be unambiguously distinguished by computer programs, which is sufficient for the proper functioning of AI algorithms. Furthermore, it is worth noting that the rectangular markings do not overlap each other, as it would present a significant challenge for an AI model to recognize such annotations. Consequently, it was not possible to fully distinguish avant-corps or oriels located on the façade, as their markings would obstruct smaller elements located on them. In this iteration of the project, the more detailed elements were omitted.

During the process, it was imperative that colour variations resulting from blurred lines and pixelation be avoided. Furthermore, it was crucial to utilize rectangles as opposed to curved shapes for the labelling of elements, and to maintain accuracy. The finished files were to be accompanied by a legend, which would include information on all the elements specified during the marking, along with their numerical equivalents.

Table 2. Legend encompassing the elements considered during the annotation of façades (elaborated by authors)
Tabela 2. Legenda obejmująca elementy uwzględniane podczas anotacji fasad (oprac. autorzy)

Element	[R] in code	Type	[G] in code
Wall	30	smooth plaster	210
		textured plaster	211
		brick	212
		bossage	213
Portal	200	plain	40
		ornate	41
Door	110	rectangular	30
		semicircular arch	31
		curtain	32
		other – difficult to determine	33
		passage	34
Window surround	250	plain	91
		jamb	92
		aedicula	93
		other	94
Window	240	rectangular	230
		semicircular arch	231
		curtain	232
		difficult to determine	233
Pediment	230	straight	190
		triangular	191
		broken	192
		segmental	193
		recessed	194
		scroll	195
		other	196
Cornice/ horizontal element	80	stringcourse	150
		sill course	151
		cornice	152
		sill	153
		frieze	154
Pilaster/ vertical element	60	pier	20
		pilaster	21
		column	22
		engaged column	23
		pilaster strip	24
Balcony	140	openwork balustrade	100
		solid balustrade	101
		loggia	102
Roof	160		10
Detail	180	gable/pediment/attic	50
		turrets	51
		plain panel	52
		decorative panel	53
		decorative element (flat detail without frame)	54
		other – sculpture, specific, etc.	55
		brackets/console	56
Noise	0		0

Style	[B] in code
no style – cannot be determined	0
Romanesque Revival	10
Gothic Revival	20
Italian Renaissance Revival	30
Northern Renaissance Revival	40
Baroque Revival	50
Neoclassicism	60
Art Nouveau	70
Modernism	80
Secondary, disruptive element	90

Examples	
110_30_0	
240_230_80	
200_40_20	
250_94_70	
230_190_90	

The terminology is consistent with the Getty Art & Architecture Thesaurus (Getty Research Institute 2021).

Fig. 3. Example tenement from the dataset (Kościuszki Street 14, Wrocław):
a) photograph before geometric correction, b) annotated image (photo by J. Tyburczy, annotated by M. Biegańska)
Il. 3. Przykładowa kamienica ze zbioru danych (ul. Kościuszki 14, Wrocław):
a) zdjęcie przed korekcją geometryczną, b) zaanotowany obraz (fot. J. Tyburczy, anotacja M. Biegańska)

It was also of significance to consider the noise elements present in the photographs. In the majority of cases, it was not possible to remove the objects from the image, therefore one of the steps of the annotation process was to mark these elements on a separate layer. In order to clearly distinguish between the noise and façade components, a specific RGB code was assigned to the noise. It identified all elements that were not included in the aforementioned legend, such as greenery, vehicles or antennas.

To ensure the integrity of the data, a spreadsheet was created, containing all necessary information regarding the façades and their annotations. The structure of the spreadsheet is illustrated in Table 3.

Along with the spreadsheet, two additional folders were created: one for storing the finished PSD files, and one for storing the annotators' notes. The files supplement the information of each tenement. Overall, the complete data on each tenement contains its original photographs, the photograph selected for annotation, the annotated image and the annotator's notes. The spreadsheet serves as the point of reference for all files. This solution facilitates data filtering and communication among users of the collection.

Verification of annotations, reconciliation of descriptions

Following the annotation of selected photographs of tenements, the acquired data was verified by a domain expert in the history of 19^{th} and early 20^{th} century architecture. In order to ensure the accuracy of the annotations, the works created in the graphic software were compared with the annotator's own notes and the base photo of the tenement. To further ensure the uniformity of interpretation, one individual was designated as the arbiter of final decisions. In instances of dispute or ambiguity, the expert group was expanded. Ultimately, however, the final decision rested with the chief content supervisor.

Both the technical and content-related aspects were verified. In particular, the accuracy of labelling was assessed, as well as the conformity of colours with the author's notes and the legend. The file export method was also examined, as were the labelling and structure of layers in the file. In instances of non-conformity, the work was submitted for correction, and upon completion of the requisite changes, it was subjected to another examination.

Once more, references were made to the aforementioned summary spreadsheet. In order to organize all processes, the spreadsheet was extended to include additional columns for annotator data, work status, hyperlink to the exported annotation file, annotator's notes and verification status. This allowed for the ongoing progress of the work to be tracked, as well as for faster feedback or correction in case of problems or errors.

Stage III. Summary of the dataset

Description of the generated dataset and transfer it for use in the machine learning process

In the end, the collection of façades of historic tenements consists of 1,200 photographs. Among the 1,148 total photos of façades, 400 were annotated. The basic elements present on the façades, characteristic of each style, were marked. Elements that may disrupt the analysis were also highlighted. A total of 11 elements, 46 types, and 8 styles were distinguished on the annotated elevations. Thanks to the large number of annotations, we can create summaries

Table 3. Structure of the reference spreadsheet (elaborated by authors)
Tabela 3. Struktura arkusza kalkulacyjnego służącego do porządkowania danych (oprac. autorzy)

Tenement name	Accepted	Style	Photograph file	Assigned	Progress	PSD file	Annotator's notes	Other notes
District street_ number		…	url	name, surname		url	url	…

Legend:
Tenement name: The name of the photograph based on the aforementioned naming schema.
Accepted: Indicator whether the photograph was accepted or rejected for annotation (the green colour indicated acceptance).
Style: The tenements or its particular elements styles.
Photograph file: Hyperlink to the photograph fie.
Assigned: Annotation assigned, with optional distinguishment by the colour of the field.
Progress: Annotation progress, colour coded: blue indicated work in progress, orange the need for verification, green – the work being finished and approved.
PSD file: Hyperlink to the completed PSD file.
Annotator's notes: Hyperlink to the annotator's notes.
Other notes: Notes and comments.

that show both the percentage of occurrence of individual elements (Fig. 4) and more detailed information on the occurrence of their types (Fig. 5).

The collection was submitted for experiments to verify its potential applications in machine learning, as shown in the second article[2]. As stated earlier, one of the evaluated tasks will be semantic segmentation, where an AI model will be trained to automatically locate and classify the elements present.

Summary

Intelligent techniques can support the process of designing in accordance with the historical context, analysing and optimizing the spatial layout of buildings in terms of functionality, ergonomics and space efficiency. Many specific applications can be mentioned, but the prerequisite for AI's success is providing the large datasets needed to train and test the AI models.

Many datasets are publicly available; they are helpful in the evaluation and comparison of methodological approaches to problems in multiple fields, including Architecture. Such datasets are called benchmarks.

This article presents the process of creating a dataset *NeoFaçade* containing images of historic tenements in Wrocław and indicates its potential for machine learning. The project aimed to gather high-quality photographic material and accurately annotate architectural elements, enabling the dataset to be used in various image processing tasks in Architecture.

The dataset construction considered the unique characteristics of Wrocław's tenements, making the collection rich and versatile. Special attention was paid to precise image annotation, resulting in high-value data for machine learning algorithms, such as semantic segmentation, image classification, and generating tenement house façades.

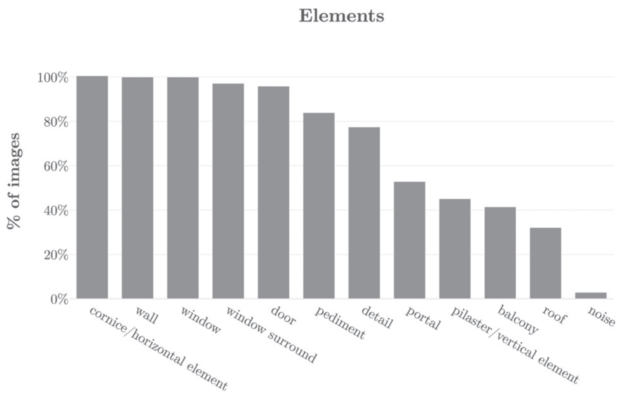

Fig. 4. Percentage occurrences of elements in the *NeoFaçade* dataset (elaborated by authors)

Il. 4. Procentowe występowanie elementów w zbiorze *NeoFaçade* (oprac. autorzy)

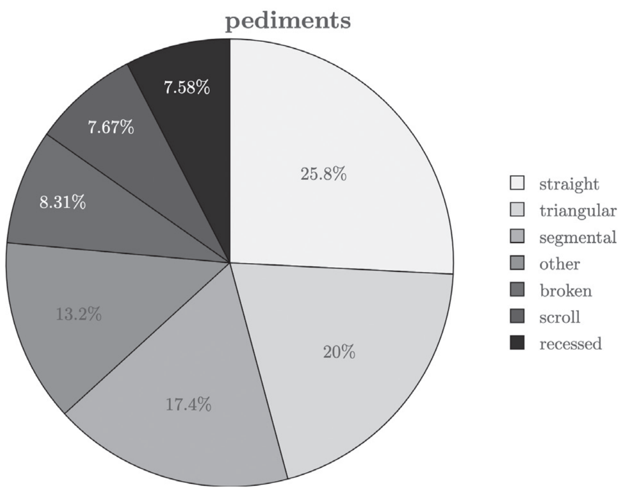

Fig. 5. Example analysis of one of the elements: number and types of pediments occurring on the façades (elaborated by authors)

Il. 5. Przykładowa analiza jednego z elementów: liczba oraz typ naczółków występujących na fasadach (oprac. autorzy)

[2] Halina Kwaśnicka, Bianka Kowalska, Hubert Baran, Daniil Hardzetski, Aleksandra Marcinów, Małgorzata Biegańska. "Analysis of the New Architectural Dataset NeoFacade and Its Potential in Machine Learning." Submitted to *Architectus* (2024).

The article also addresses the challenges associated with data acquisition and annotation, proposing possible solutions. The dataset was compared with existing benchmarks, confirming its high quality and research potential.

According to Kistowski et al. (2015), the key characteristics of benchmarks are:

1. Relevance to the planned tasks in a specific field.
2. Reproducibility – similar results are produced when the benchmark is run with the same test.
3. Fairness – different test configurations compete on their merits without artificial limitations.
4. Verifiability – providing confidence that a benchmark result is accurate.
5. Usability – users can run the benchmark in their test environments without roadblocks.

We have ensured that the developed *NeoFaçade* dataset meets the above requirements. The usefulness of the set is initially verified.

Looking ahead, the research team has ambitious plans for the dataset. The focus will be on expanding it with new photographs from different parts of Wrocław and cities with similar styles of buildings, such as Szczecin and Berlin. Additionally, the collected data will be used to train advanced machine learning models, with potential applications in architectural practice, heritage conservation, and urban planning projects.

The dataset of historic tenements in Wrocław can potentially become a valuable tool supporting innovative research projects and practical applications.

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Streszczenie

Budowa zbioru danych historycznych kamienic Wrocławia. Anotacja zdjęć do wykorzystania w uczeniu maszynowym

W ostatnich latach rozwój sztucznej inteligencji (SI) wprowadził nowe możliwości także w dziedzinie architektury. W obszarze analizy kompozycyjnej i rozpoznawania detali architektonicznych SI może mieć istotny wpływ na wspieranie badań historyczno-architektonicznych poprzez waloryzację zabytkowych budynków oraz projektowanie zgodne z historycznym kontekstem. Skuteczne wykorzystanie SI w analizie obiektów architektonicznych wymaga jednak dostarczenia dużych zbiorów danych niezbędnych do trenowania i testowania modeli. Celem autorów artykułu było przedstawienie procesu tworzenia zbioru danych zawierającego anotowane zdjęcia. Opracowana metodologia tworzenia zbioru składa się z trzech etapów: przygotowania procedury pozyskiwania danych, przetwarzania danych – utworzenia zbioru danych spełniających wymagania oraz podsumowania zbioru danych. Wszystkie etapy zostały w pracy szczegółowo omówione wraz z pokazaniem przykładowej anotacji jednej z kamienic. Zbiór *NeoFaçade* służy jako historyczny zbiór danych zawierający fasady kamienic z XIX i XX w. z Wrocławia, a w przyszłości także z innych miast o podobnych stylach architektonicznych (np. Szczecina czy Berlina). Zgromadzenie wysokiej jakości materiału fotograficznego i dokładne oznaczenie elementów architektonicznych umożliwia wykorzystanie zbioru danych w różnych zadaniach sztucznej inteligencji: segmentacji semantycznej, klasyfikacji obrazów, a także w generowaniu elewacji kamienic. W ten sposób zbiór *NeoFaçade* może być zastosowany w praktyce architektonicznej czy w konserwacji zabytków.

W przyszłości zespół badawczy skupi się na rozszerzeniu o nowe fotografie zbioru, jednocześnie będzie starał się pokazać, że *NeoFaçade* jest wartościowym narzędziem wspierającym innowacyjne projekty badawcze i praktyczne zastosowania.

Słowa kluczowe: zbiór danych, fasada, kamienica, historyczna architektura, uczenie maszynowe