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Segmentation of Parcel Boundary Indications in Very High-Resolution Orthophoto Mosaics for Control Point Identification

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Abstract: Several Land Parcel Geometry issues in Indonesia's Land Registration Process, such as parcel overlapping, gaps between parcels, and incorrect parcel shapes and sizes, are currently being addressed through a block adjustment approach. One crucial aspect of the block adjustment process is determining control points that tie the parcel geometry to the land coordinate system. Detailed Observations and measurements of parcel points in the field and aerial photographs established these control or tie points. Rectifying land parcels requires many control points, requiring substantial time and effort. The automation phase is critical to expedite the control point identification process. This research uses artificial intelligence techniques to identify control points in very high-resolution orthophoto mosaics. The method employed for control point identification involves the Segment Anything Model (SAM) algorithm to segment parcel boundary indications accurately. Enhance the quality of segmentation results conducted by fine-tuning, followed by centerline extraction and refinement of the extracted data. Based on the segmentation, a SAM model capable of accurately segmenting building objects is attained, After the centerline extraction process and modifications to the existing geometric operations within the GIS Tool, at the edges of buildings, fences, and walls derived points. These points can serve as control point indications in the block adjustment process.

Keywords: *ortophotos, control point, block adjustment, automation*

Introduction

The acceleration of the Comprehensive Systematic Land Registration Program (PTSL) continues to address various land-related issues such as land disputes, conflicts, discrepancies in land parcel shapes between the National Land Agency (BPN) and the Land and Building Tax (PBB), and other related problems [1]. The outcomes of PTSL are stored in a land geodatabase used to manage all land data. In the process of compiling spatial land data, issues persist regarding land parcels, including duplicate parcels, overlaps and gaps between parcels, incorrect shapes and positions of parcels relative to field conditions, and the lack of integration of adjacent parcel boundaries.

These issues have prompted the development of a parcel data adjustment method based on a block adjustment algorithm [2]. In this method, each parcel is adjusted against control points predetermined or measured by operators or surveyors. The concept of block adjustment was initially developed by [3], and a similar study conducted by [4] presented the concept of block adjustment to merge separate parcel blocks.

One challenge in the block adjustment process is determining control points for each parcel block. A parcel block is a collection of neighboring land parcels. Each parcel block requires a minimum of 4 control points, and this number increases if the shape of the parcel block is more complex. Control points in block adjustment must be identifiable points at the corners of parcels, either from orthophotos or satellite images, or from field measurement points. The determination of control points is a relatively time-consuming process, requiring the understanding of operators/surveyors in grasping the concept of these control points.

The automation of control point determination can be achieved by leveraging high-resolution orthophoto data and artificial intelligence methods. Orthophotos provide raster data with very high resolution, supporting the automation process through artificial intelligence-based segmentation [5]. Segmentation for land parcel boundaries using deep learning has been developed [6]. In this study, the latest deep learning technology, SAM [7], will be employed to perform automatic segmentation on orthophoto data. The goal of this research is to utilize deep learning technology to generate indicative control points used in the block adjustment process.

Methods

Pada penelitian ini, area yang digunakan adalah area This study focuses on the Nusa Hijau Permai complex in Cimahi, featuring diverse building types—regular, semi-regular, and irregular. The segmentation process utilizes an orthophoto from April 2023 with a Ground Sampling Distance of 5 cm and an accuracy of 12.4 cm, meeting 1:1000 class 1 map standards for land administration. Very high-resolution orthophotos enhance the accuracy of automatic segmentation.In the Adumanis block adjustment process, control points are crucial references for parcels within a block. **Figure 1** in the Adumanis flowchart illustrates the research position.

In the Adumanis flowchart, each stage serves a specific function. In the "Parcel Block Formation" stage, neighboring parcels are grouped to form a parcel block. The input for this stage includes the distance between parcels, which guides block determination. The next step is "Control Point Identification," where control points for each block are determined. These control points can be identified from orthophotos, such as building corners or fences, and can also be derived from field measurements. Control point determination in the Adumanis stage is time-consuming, so automatic segmentation is employed to streamline the process. The subsequent step is "Weighting Process," where each control point is assigned a weight based on its accuracy. The final stage is the "Parcel Block Adjustment" process.

In this research, Artificial Intelligence technology is employed for automatic segmentation, utilizing the Segment Anything Model. This foundational model is trained on 11 million photos and 1 billion masks, ensuring SAM produces highly accurate segmentation results. **Figure 2** illustrates the architecture design of the SAM model.

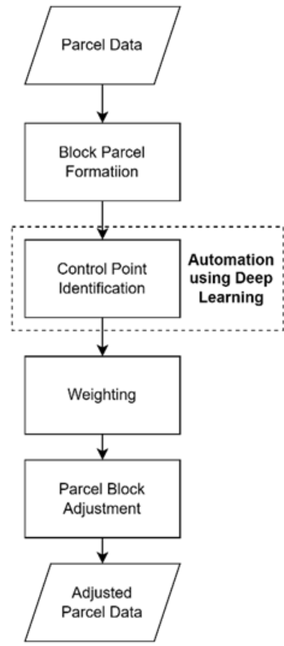

Figure 1. Adumanis workflow

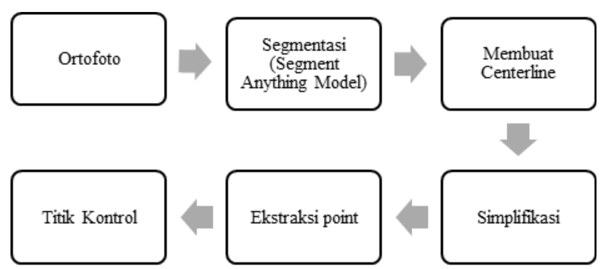

Figure 2. Automation Workflow

High-resolution orthophoto data is used for the segmentation process. SAM generates vector segmentation outputs and operates as a zero-shot model, meaning it segments all objects in the orthophoto. The segmentation process with SAM is executed using ArcGIS Pro 2.0. The research stages are depicted in **Figure 3**.

Explanation regarding the automatic segmentation flow is as follows:

1. Segmentation (Segment Anything Model): Utilizes deep learning to segment orthophotos, producing polygon vector objects on the orthophoto.
2. Create Centerline: Generates a centerline from the polygon gaps resulting from SAM segmentation. The

centerline data is in polyline form and serves as a reference for control point determination.

3. Simplification: Simplifies the centerline points for a neater form, employing the Douglas-Peucker method in the simplification process.
4. Point Extraction: Extracts control points from the endpoints of the centerline. The output of the point extraction is indicative control points used in the Adumanis control point determination stage.

Results And Discussions

The initial stage of the research involves the segmentation process using the SAM model. In the SAM model segmentation process, the first step is to input hyperparameter values. The hyperparameter values used in this study are presented in **Table 1**.

Table 1. Hyperparameter value in SAM

Hyperparameter	Value
Box_nm threshold	0.8
Point per batch	256
Stability score	0.9
Min-max region	250
Padding	256

The output from SAM is a vector representation of buildings, as depicted in **Figure 4**. The polygons generated by SAM are vector data with a zero-shot characteristic, meaning each segment of the building is segmented separately, such as the building and roof being segmented independently. In this study, there is no need for a polygon merging process to form buildings since the output consists of control points.

The next step is the process of extracting a centerline from the polygon gaps. In this process, the gaps formed from the SAM segmentation polygon are transformed into lines. In this study, before extracting the centerline, a buffer process is conducted with a value of -0.05 meters. This step is taken to create larger polygon gaps and minimize polygons that overlap. **Figure 5** displays the centerline formed between the polygon gaps.

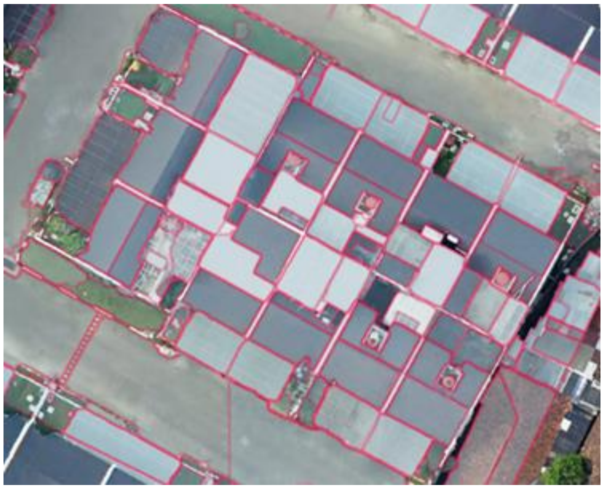

Figure 3. SAM result

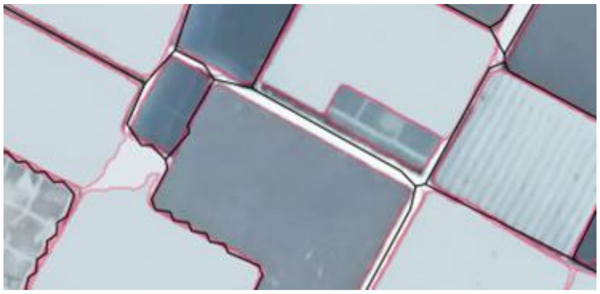

Figure 4. Centerline between polygon

After obtaining the centerline, the next steps involve the simplification process and point extraction. In the point extraction process, the resulting points include both endpoints and intersections of each polyline. Therefore, point filtering is performed to select points indicating the ends of buildings. The filtering technique involves creating a guidance vector to determine the direction and distance of block translation. The selected control points meet criteria if a point is found within a 50 cm radius of the guidance vector's end and has a degree of 3 in the segmentation processing from the previous stage. **Figure 6** displays the output of control points after filtering.

From the generated points, the next step involves the block adjustment process. The image displays the results of the block adjustment. In the Adumanis outcome, there is a change in area with a difference of 4-6% from the initial area. Additionally, there is a shift of parcels towards the control points, resulting in parcels that now

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have positions and shapes consistent with the actual conditions.

Figure 5. Control Point Indices from SAM segmentation

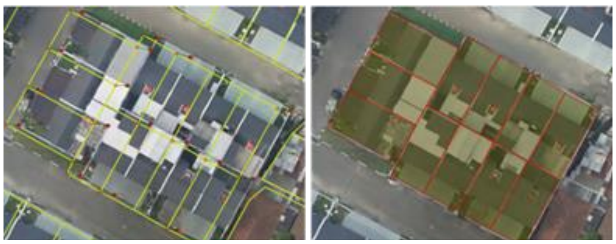

Figure 6. Before and after adumanis

Conclusions

Based on the research results, it is evident that utilizing SAM segmentation on very high-resolution orthophotos can yield accurate building object segmentation. To obtain indicative control points, the process involves creating a centerline, simplification, and point filtering, resulting in accurate indicative points. In this study, the generated control points are situated at the ends of the residential areas. After conducting the block adjustment process, referencing these control points, the adjusted parcels are obtained. Consequently, the parcels have positions and shapes in accordance with actual conditions, identifiable from the very high-resolution orthophotos. The block adjustment results reveal a change in area ranging from 4% to 6% compared to the previous area, still well within the tolerance of the required area change, which is below 10%.

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