
# INVESTIGATION OF AVAILABILITY REMOTE SENSED DATA IN CADASTRAL WORKS

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## Introduction

Cadastre, which is defined legal status and rights specifying the boundaries of the immovable property on the land and map is very important in relation to property. In countries like Turkey that require high precision, in cadastral survey data used in the cadastral work to ensure that precision plays an important role. Less costly and more efficient studies should be used for improve suitability to the original on cadastral maps. Therefore, availability of alternative measurement methods like photogrammetry and remote sensing in this kind studies should be explored. Geographical data which generated with sub meter precision via photogrammetric and remote sensing methods will also help to gain time and speed in preparation of the cadastral maps.

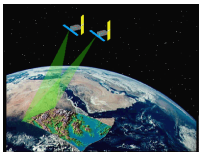
## Data Collection Techniques Used in Existing Cadastre

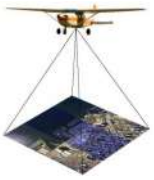
Existing cadastral measurement techniques can be classified as direct and indirect.

- Direct techniques, is the process determining the points on land by measuring angles and distances with the help of classical measurement equipment. Coordinates and the area of each parcel in the field are calculated using mathematical methods.
- In indirect techniques, position information of the objects is obtained by using GPS, remote sensing and photogrammetry techniques. If we want to group the cadastral data collection techniques we can categorize as a simple; classical measurement techniques, GPS technique, photogrammetric techniques and remote sensing techniques. While terrestrial survey techniques identified directly, other operations can be described as indirect techniques.



## Data Collection Techniques Used in Existing Cadastre








Data Collection Techniques Used in Existing Cadastre

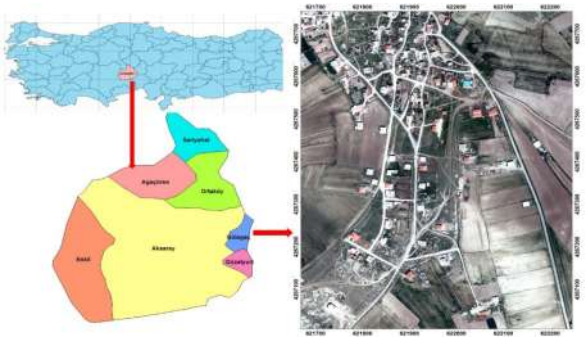
## Data Collection Techniques Used in Existing Cadastre

After 1950, in our country, aerial photogrammetry was emphasized and was applied as actively after 1955 in order to accelerate land cadastre works. Nowadays, orthophotos that created by the elimination of geometric and projective errors is used to a significant extent in many disciplines. In many studies, orthophotos that presented in precisions of submeter can minimize the level of labor and cost. In order to display and observe the Earth, the images taken from satellites which sent to space were actively used in many areas (map, geology, forestry, agriculture etc.) due to improved technology. Nowadays, remote sensed data are used for many purposes. One of these applications is the use of very high resolution remotely sensed data in cadastre applications. Especially, satellite images, due to spatial resolution down to 40 cm, plays an important role in for providing many spatial data (buildings, roads, historical, structures, water resources, energy resources, etc.) that required in cadastre work. Studies about the availability of remotely sensed data in the cadastral work has increased in recent. In addition, feasibility of the cadastre work with unmanned aerial vehicles was examined.



## Pilot Study Area

Aksaray which is selected as the pilot area has flat land structure in the central Anatolia region of Turkey. Application put in process at Gülağaç/Yalman district of Aksaray.



Study Area: Aksaray/Gülağaç

## Data Used in Application

In study, orthophotos of Aksaray was used as basic data which have 30 cm spatial resolution. Cadastral data of study area (parcel boundary, building, road, etc.) was used for the purpose of comparison. In Application was benefited from; Erdas Imagine and e-Cognition Developer software for raster data, ArcGIS and NetCAD software for vector data.



## Obtain of Geographic Data Using Orthophoto

A lot of object extraction method was come into use with remote sensing thanks to developing and innovating technology. Roads, buildings, rivers, farmlands details can be easily determined with object extraction from remotely sensed data. In addition to that, extraction and detection of unregistered buildings by using orthophotos is predicted.

Three methods were used for the purpose of extracted geographical objects from the orthophoto, including;

- ✓ Object-based classification
- ✓ Pixel-based classification
- ✓ Digitizing

In this study, with these methods, classification of buildings and roads has been applied by using basic cadastral data. Classification results were directly compared with cadastral data and accuracy was investigated.

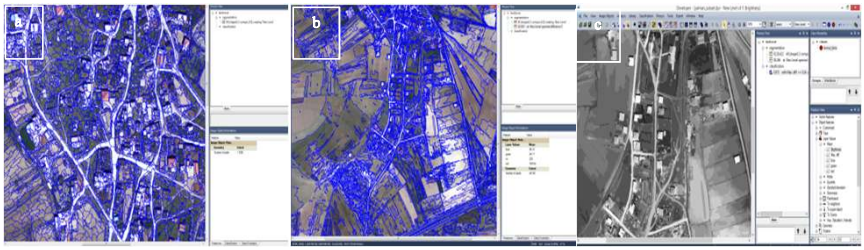
## Object Based Classification

The extraction of the object is made out of orthophotos in the pilot process. Processing steps are as follows, respectively;

- Segmentation Process; Determination of the group of objects to be created for classification
- Determination Precision of Segmentation; Generated segments are redefined according to the sensitivity of the object requested to be extract.
- Creating The Appropriate Function; Generate function from the band values to distinguish details
- Classification; Classification process according to the specified function
- Detail Controls; Checking out the details of the classification result



## Object Based Classification




Segmentation Process (a), Detect Precision of Segmentation (b), Generate Function (c)


Classification (a), Detail Control (b)

## Pixel Based Classification

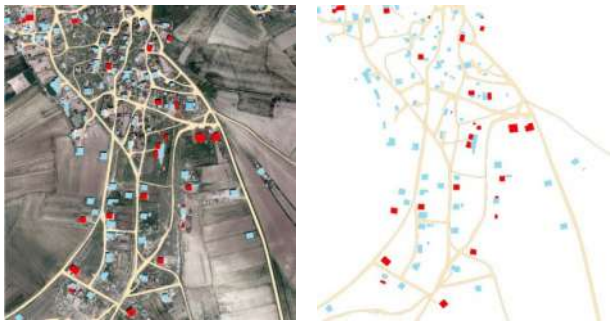
Training data selected from object based classification was also used for pixel based classification. During application, classification process has been made with maximum likelihood algorithm which is commonly used. Land cover of classification process generated from 3 classes including build, roads and other. Pixel based classification process, because of perform on the spectral brightness of pixel values, not classified or misclassified pixel may occur. Raster data obtained from pixel based classification has been converted to vector data for use to comparison.

Pixel Based Classification and Raster-Vector Conversion



## Digitizing and Present Cadastral Data

Orthophoto map digitized by hand for compare with cadastral data and the other obtained data. Manuel digitized map is shown below;



Manual Digitizing

## Digitizing and Present Cadastral Data

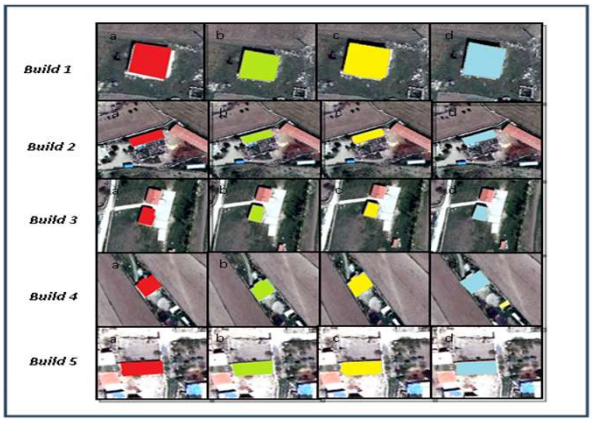
Existing Cadastral Data

Present cadastral data belonging to Aksaray province used as main comparison material. In this figure, screenshot of the cadastral data is displayed. There are all objects that are subject to real property in the cadastral data.



## Comparison of Cadastre and Produced Data From Orthophoto

Some selected objects produced from orthophoto compared with present cadastral data. These are 5 buildings, 3 dirt roads and an asphalt road. Details and geometric comparisons of 5 different buildings produced with terrestrial data (*a*), manual digitizing (*b*), object based classification (*c*) and pixel based classification (*d*) is shown at figure. Samples of asphalt road and dirt roads and comparison results seen at next figures




Comprasion of Building, (a) Cadatsral Data, (b) Manual Digitizing, (c) Object Based Classification, (d) Pixel Based Classificaiton

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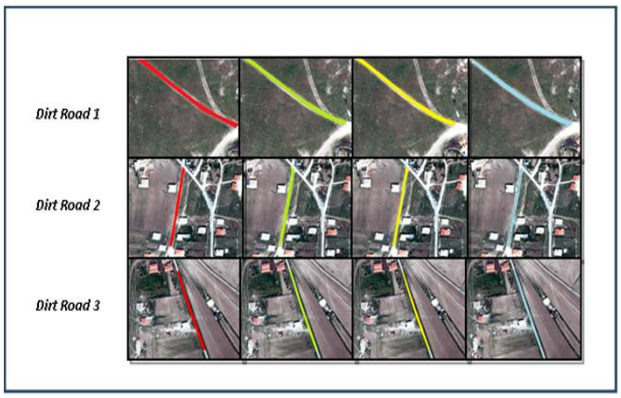


Comprasion of Dirt Roads results, (a) Cadatsral Data, (b) Manual Digitizing, (c) Object Based Classification, (d) Pixel Based Classificaiton



## Comparison of Cadastre and Produced Data From Orthophoto

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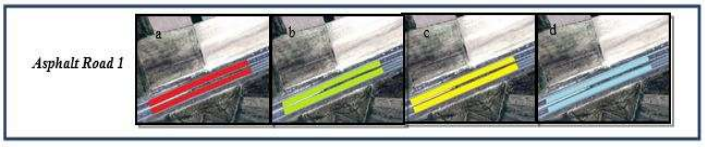



Figure 10: Comprasion of Asphalt Road, (a) Cadatsral Data, (b) Manual Digitizing, (c) Object Based Classification, (d) Pixel Based Classificaiton

## Assessment of Results ( Areal )

| DETAIL | Cadastre(Reference) | Digitizing | | Object-Based | | Pixel-Based | |
|---|---|---|---|---|---|---|---|
| | m² | m² | % | m² | % | m² | % |
| Build 1 | 157 | 146 | 92,99 | 142 | 90,44 | 139 | 88,53 |
| Build 2 | 122 | 125 | 97,60 | 121 | 99,18 | 113 | 92,62 |
| Build 3 | 156 | 163 | 95,70 | 167 | 93,41 | 160 | 97,50 |
| Build 4 | 163 | 174 | 96,93 | 157 | 97,54 | 171 | 95,32 |
| Build 5 | 234 | 226 | 96,58 | 221 | 94,44 | 253 | 92,49 |

Comparison of Buildings Areas by using different methods

| DETAIL | Cadastre(Reference) | Digitizing | | Object-Based | | Pixel-Based | |
|---|---|---|---|---|---|---|---|
| | m² | m² | % | m² | % | m² | % |
| Dirt Road 1 | 215 | 225 | 95,55 | 207 | 96,27 | 185 | 86,04 |
| Dirt Road 2 | 736 | 713 | 96,87 | 721 | 97,96 | 647 | 87,90 |
| Dirt Road 3 | 946 | 908 | 95,98 | 912 | 96,40 | 851 | 89,95 |

Comparison of Dirty Roads Areas by Using Different Methods

| DETAIL | Cadastre(Reference) | Digitizing | | Object-Based | | Pixel-Based | |
|---|---|---|---|---|---|---|---|
| | m² | m² | % | m² | % | m² | % |
| Asphalt Road | 3001 | 2918 | 97,23 | 2892 | 96,36 | 2656 | 88,50 |

Comparison of Asphalt Road Area by Using Different Methods



## Statistical Analysis for Results

The coordinate values of the each object (building and roads) are statistical analyzed by cadastral data as reference. Standard deviations eq. (2) obtained using divisions eq. (1) and means of the coordinate values. Shown in eq. (1) $\bar{x}$ is presented arithmetic means values of coordinates eq. (4), $N$ is number of point ($i=1,2,3....N$) and $x_i$ is coordinates of objects data. With presented $s$, standard deviation obtained with benefit from differences and mean of coordinate values.

$$\bar{x} = \frac{1}{N}\sum_{i=1}^{N} x_i = \frac{x_1 + x_2 + \cdots + x_N}{N} \quad (1)$$

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \bar{x})^2}, \quad (2)$$

$$s_{mean} = \frac{s}{\sqrt{N}} \quad (3)$$

$$H_0: d=0 \qquad d = x_{mean1} - x_{mean2} \quad (4)$$

According to the $t$-distribution table, surveyed coordinates (cadastre survey) with mean values obtained from methods (pixel based class., object based class. and digitizing) are expected to be equal. Therefore, foreseen that situation of between statistically expected difference values and calculated difference values equal to zero $H_0$: hypothesis. $H_0$ hypothesis is given eq.4. Also eq. 4 is shown means of cadastre coordinates ($x_{mean1}$) and coordinates calculated from other methods ($x_{mean2}$).

## Statistical Analysis for Results

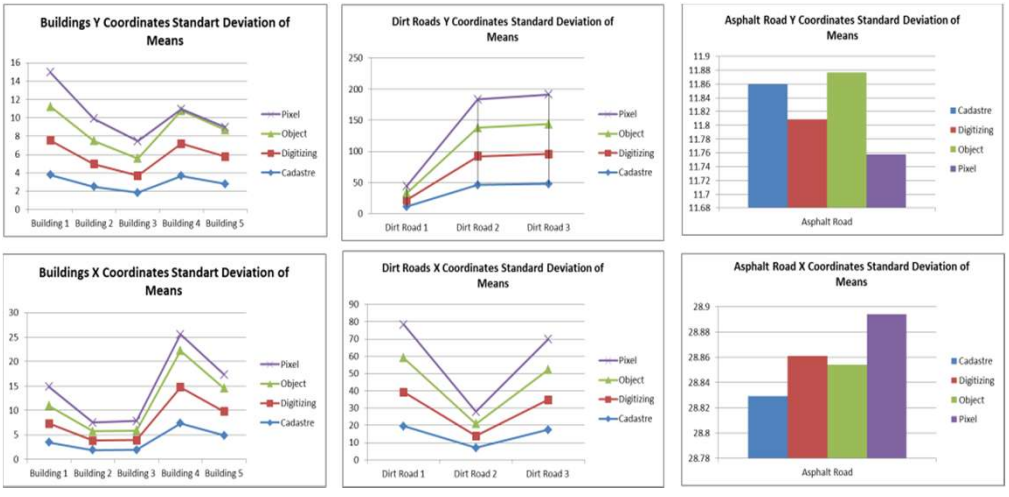
- Whether there is statistically significant difference values are determined through shown in eq. 5 t-distribution confidence limit of test value $t_{\infty,\ 1-\alpha/2}$.

$$T_i = \frac{|d_i|}{s_{di}} \sim t(f) \qquad (5)$$

- Where $s_{di}$ is standard deviation of the difference $d_i$. In case of $T > t_{\infty,1-\alpha/2}$ coordinates calculated for each object from the mean values of each methods (object based class., pixel based class., manual digitizing), the deviation from the mean of the cadastral measurements are expressed as statistically significant. Otherwise ($T < t_{\infty,\ 1-\alpha/2}$) changes is statistically insignificant.



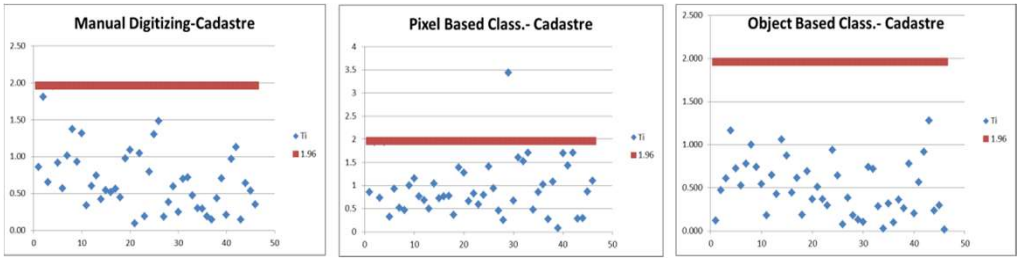
## Statistical Analysis for Results




Self Accuracy Determination of Methods

## Statistical Analysis for Results

Each method compared with cadastral data which accuracy is accepted as higher than others Mean values of three methods are subtract to cadastral mean values for t-distribution confidence interval. This results shows that these are statistically insignificant according to t-distribution ($t_{\infty, 1-\alpha/2}=1.96$) %95 confidence interval. Test values of dirt road results are statistically significant in pixel based classification method. For this reason, it can be said that there is unclassified pixels on some objects.




According to t-distribution, results obtained from pixel,object and digitizing methods comparison with cadastral surveys.



## Statistical Analysis for Results

Pixel based classification distributed heterogeneous under the threshold. This shows that the coordinates have low accuracy their own. The reason for this, unlike object based classification, is each pixel evaluate individual in pixel based classification. Besides, because of digitizing was made by manual, encountered some errors in coordinates. These errors originated from digitizer eye error and shadows of builds. As a result of statistics it is seen that coordinates didn't have homogenous distribution at manual digitizing technique. According to the results can be seen that the optimal distribution of standard deviation of coordinates in object-based classification technique. When methods compared statistically with each other shown that object based classification technique gave higher accuracy results than pixel based classification and manual digitizing. These results supporting by statistical analysis showed that object based classification method available on object extraction such as buildings and roads from orthophotos in cadastral works.

## Results

- The results show that best accuracy result is getting from object based classification when methods coordinates compared with cadastral coordinates.
- Besides, comparing area of objects (building and roads) with area getting from cadastre, in this study reached more than statistically %95 accuracy in digitizing and object based classification methods.
- Results have shown that producing data from orthophotos can be provide high accuracy results depending on resolution of aerial photos.
- According to accuracy results, it could be said that digitizing and object based classification methods be useful in studies which are needed precision similar with orthophoto resolution.
- For cadastral works, remote sensed data can be used to extract spatial data for second cadastre, cadastre renovation, cadastral update and multipurpose cadastre.
- Besides, it can be said that unregistered or not yet registered structures/buildings which are keep rising day by day, easily detect on orthophotos. When spatial resolution of remote sensed data improves in the future, object extraction methods from orthophotos/satellite images can provide facilities for cadastral works.