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Crop Area Estimation from UAV Transect and MSR Image Data Using Spatial Sampling Method

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Abstract

Using remote sensing data to estimate crop area is efficient to a wide range of end-users, including government agencies, farmers and researchers. Moderate spatial resolution (MSR) image data are widely used to estimate crop area. But its accuracy can't meet the demands of precision. Spatial sampling techniques integrated the strengths of remote sensing and sampling survey are being widely used. This method need large sample size which is cannot be guaranteed by remote sensing due to weather. The Unmanned Aerial Vehicle (UAV) can be used as an effective way to guarantee enough sample size. This paper proposed a spatial sampling method using MSR image classification results and UAV transects, a stratified random sampling method was proposed, area-scale (from MSR image classification) was used as auxiliary variable to guide the distribution of UAV transects, which had proved that 2% sampling ratio can make the crop area estimation accuracy more than 95% with a 95% confidence interval.

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Keywords: rice area rstimation; UAV Transect; Moderate spatial resolution image; sampling; classifiation accuracy

1. Introduction

Agriculture plays an important role in a country's economy. Comprehensive, reliable and timely information on agriculture resource is very necessary for a country to make decisions for all agricultural related problems. Remote sensing has shown great potential in agricultural land use mapping and monitoring due to its advantages over

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traditional procedures in terms of cost effectiveness and timeliness in the availability of information over large area [1]. The first problem of the agriculture related problems to be solved is the crop area estimation precision. With the development of remote sensing technology, Medium resolution satellite (MRS 10-60 m) image is gradually to ensure large area coverage, but classification accuracy is hard to over 85% [2], cannot meet the accuracy requirements of the agricultural statistics and other applications [3]. Classification accuracy of the high-resolution data (<5m) can exceed 95%[4], which can meet the requirements of the application accuracy, but it is subject to the limitations of width and revisit cycle, cannot ensure large crop area coverage, cannot even meet the sampling requirements [5]. With the support of the 3S (RS,GIS,GPS) technology, spatial sampling method which combine remote sensing and sampling survey have been widely used, ground survey is an important means to obtain sample, The shortcomings of the ground investigation are survey intensity and high cost [6]. In recent years, unmanned aerial vehicles (UAV) characterized by mobile and flexible, are widely used in civilian areas, they have potential to reduce survey costs, to ensure the high-resolution data obtained, lower ground survey intensity. UAV remote sensing data have been used to numerous applications in natural resources management [7], which verify that UAV remote sensing data can supplement or replace part of the ground survey data. Breckenridge [8] proved that the UAV can collect wide range of image in a short period of time, the survey efficiency is much higher traditional ground survey, he foresaw that the effect to rangeland monitoring by UAV would be similar to the effect to field survey by GPS.

In order to improve crop area estimation accuracy, this paper focus on how to design sampling method using MSR image data and UAV transects. Research the relationship between rice area estimation accuracy and sampling ratio.

2. Study area and data source

2.1. Study area

Research area are 5 transects located in China Jiangsu province (Fig 1), the area of research area is 121.66 km^2. The main crops are rice, corn, soybean. The reasons for we choose this research area are as follows. The first reason is that the research area is located in the main production areas of rice. The second reason is that the research area has MSR image in the rice growing season. The third reason is that the research area is not prohibited area of UAV flight.

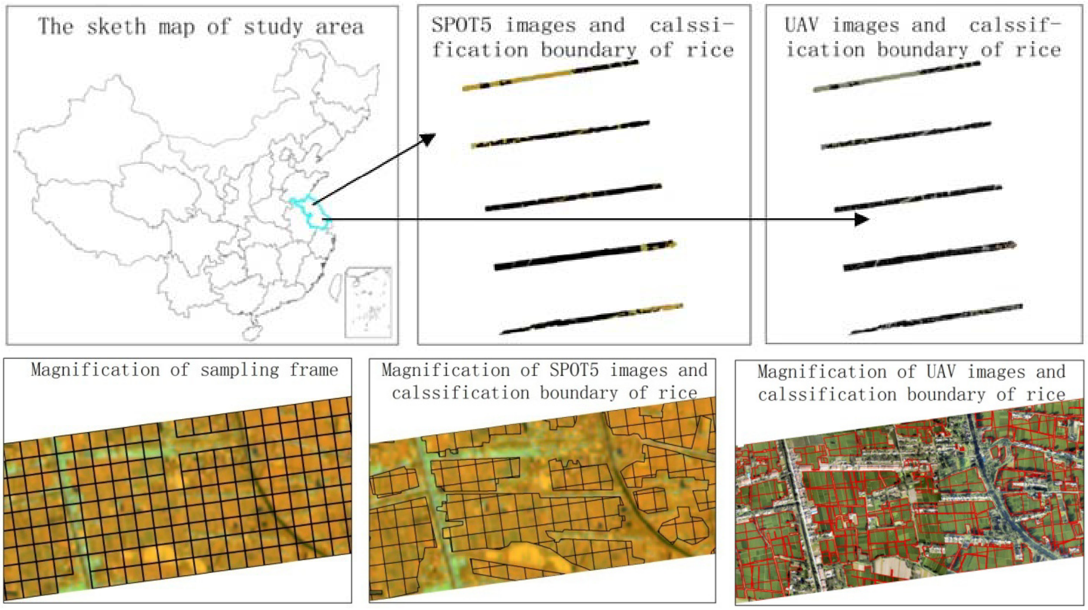

Fig.1, The sketch map of study area

2.2. Data source

2.2.1. SPOT5 Multi-spectral image and Classification of SPOT5 Multi-spectral image

SPOT5 Multi-spectral image with the 10 m spatial resolution was acquired on August3, 2014, the image coverage is 121.66 km^2, which was classified by unsupervised classification. The classification results are corrected by visual interpretation of ArcGIS software. The final rice classification results of SPOT5 image is 60.05 km^2.

2.2.2. UAV image and Classification of UAV image

UAV image were acquired from September 24 to 27, 2014, the UAV image coverage is 121.66 km^2, which were classified by visual interpretation. The final rice classification results of UAV image is 52.38 km^2.

Table 2, SPOT5 image and UAV image

data	Coverage	Rice area	Purpose
SPOT5	121.66 km^2	60.05 km^2	Sampling frame and stratification
UAV	121.66 km^2	52.38 km^2	Pseudo true value and experiment with different sampling ratio

3. Methodology

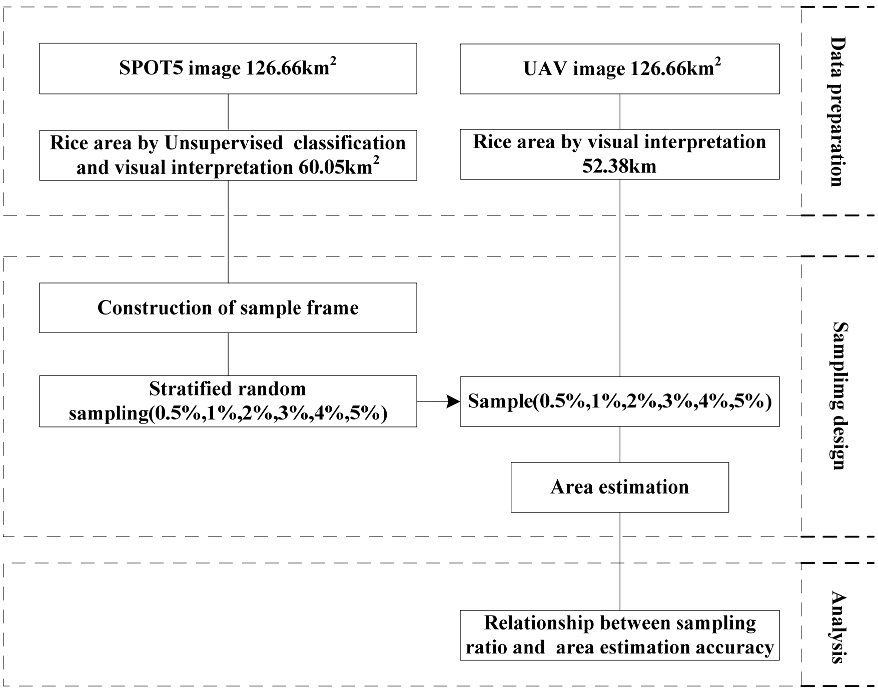

Fig.2, Flow chart of experiment

The flow of this experiment (Fig 2) includes: (1) data preparation, (2) sampling design: construction of sampling frame, stratified random sampling, area estimation, (3) analysis: Relationship between sampling ratio and area estimation accuracy.

3.1. Construction of sample frame

The final rice classification results of SPOT5 image were used to construct sampling frame, the sampling unit was designed as 0.1km×0.1km., the population is 8346.

3.2. Stratified random sampling

3.2.1. Sampling ratio determination

To research the relationship between sampling ratio and area estimation accuracy, 0.5%, 1%, 2%, 3%, 4%, 5% sample of the Population were sampled to research, and each kind of sampling ratio was sampled 30times.

3.2.2. Stratified variable definition and optimal stratification

Stratified random sampling was used to estimate rice area, which had been confirmed to be en efficient method [9].Area-scale was used as a stratified variable, because area-scale is a better auxiliary variable in stratified sampling [10]. The number of layers was design as 6. When the number of layers larger than 6, the increase of precision will be small. Unless the correlation coefficient between estimate of target variable and stratification of actual variable is larger than 0.95, there should not be more than 6 layers [11].

Determinate the layer boundaries: The cumulative equivalent frequency with square root method was used to get the optimal stratification. This method was proposed by Dalenius and Hodges [12].

3.2.3. Samples allocation

When sample size n (for example 1%) was fixed, we use Neyman allocation method to calculate the sample size of each layer, which was calculated as follow:

$$n_i = \frac{(n \times N_i \times S_i)}{\sum_{i=1}^{m}(N_i \times S_i)} \qquad (1)$$

Where n represents the sample size; n_i represents the sample size of layer *i*; N_i represents the capacity of layer *i*; S_i represents the standard deviation of layer *i*; m represents the number of layers.

3.3. Area estimation

$$\hat{P} = \sum_{i=1}^{m}(\bar{X}_i \times N_i) \qquad (2)$$

Where $\hat{P}$ represents overall point estimation; $\bar{X}_i$ represents the sample mean of layer; N_i represents the capacity of layer *i*; m represents the number of layers.

3. 4. Sampling results appraisal

Sampling results was appraised by relative error r, which is defined as follow:

$$r = 100 \times \left|\hat{P} - P\right| / P \qquad (3)$$

Where r represents relative error, $\hat{P}$ represents overall point estimation, P represents true value.

4. Results

Relationship between sampling ratio and area estimation accuracy can be seen from Fig 3 and Fig 4, at a 95% confidence interval, 0.5%, 1%, 2%, 3%, 4%, 5% sample of the Population were sampled, and each kind of sampling ratio was sampled 30times.When the sampling ratio was 0.5%, there are 8 times out of 30 sampling times relative error bigger than 5%. When the sampling ratio was 1%, there are 8 times out of 30 sampling times relative error bigger than 5%. When the sampling ratio was 2%, there are 1 time (5.27%) out of 30 sampling times relative error bigger than 5%. When the sampling ratio was 3% or 4% or 5%, all the relative error is less than 4%.

Fig.3, Relationship between sampling ratio 0.5%, 1%, 2% and rice area estimation accuracy

Fig.4, Relationship between sampling ratio 3%, 4%, 5% and rice area estimation accuracy

5. Conclusion

This study proposed a stratified random sampling method, area-scale (from MSR image classification) was used as auxiliary variable to guide the distribution of UAV transects, which had proved that 2% sampling ratio can make the rice area estimation accuracy more than 95% with a 95% confidence interval. However, this conclusion is drawn in major rice producing area, the conclusion need further study in non- major rice producing areas and hilly area.

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