Huerta, Schade, Granell (Eds): Connecting a Digital Europe through Location and Place. Proceedings of the AGILE'2014 International Conference on Geographic Information Science, Castellón, June, 3-6, 2014. ISBN: 978-90-816960-4-3

Cropland Capture: A Gaming Approach to Improve Global Land Cover

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Abstract

Accurate and reliable information on global cropland extent is needed for a number of applications, e g. to estimate potential yield losses in the wake of a drought or for assessing future scenarios of climate change on crop production. However, current global land cover and cropland products are not accurate enough for many of these applications. One way forward is to increase the amount of data that are used to create these maps as well as for validation purposes. One method for doing this is to involve citizens in the classification of satellite imagery as undertaken using the Geo-Wiki tool. This paper outlines Cropland Capture, which is simplified game version of Geo-Wiki in which players classify satellite imagery based on whether they can see evidence of cropland or not. On overview of the game is provided along with some initial results from the first 3 months of game play. The paper concludes with a discussion of the future steps in this research.

Keywords: Cropland, land cover, gaming, citizen science, crowdsourcing

1 Introduction

Accurate and reliable spatial information on cropland is essential for the estimation of potential yield losses that could occur as a result of wide spread drought or other anomalies that negatively affect crop production. Reliable cropland information is also needed for tackling other major environmental issues such as setting EU and US biofuel targets, determination of greenhouse gas emissions from different sectors including agriculture, REDD+ (Reducing Emissions from Forest Degradation and Deforestation) initiatives, and for determining the implications of climate change on crop production and patterns of productivity.

Global cropland extent can be obtained from global land cover products such as the GLC-2000 [10], MODIS [6], GlobCover [3] and the most recent 30m Chinese land cover product [17]. However, the problem with these products is that they are not accurate enough to provide a reliable estimate of croplands. For example, in Africa where there are extensive areas of low agricultural intensification, the spectral signatures and temporal profiles of cropland is similar to that of grasslands so differentiation between these two types is difficult [14]. Another issue is the lack of adequate data for training these maps using automated classification algorithms. The products also need further validation data. For this reason, the Geo-Wiki tool was developed, which is a visualization, crowdsourcing and validation tool for improving global land cover [8, 9]. Crowdsourcing [12], volunteered geographic information [11] and citizen science [2] are all terms for the involvement of citizens in data collection, analysis and scientific research of which Geo-Wiki is one of many applications.

In the past, a series of crowdsourcing campaigns were run to collect data using Geo-Wiki to help answer specific research questions regarding, e.g. land availability for biofuels [7], wilderness mapping [15] and land grabbing [1]. Although successful, we wanted to find methods for attracting larger numbers of participants and developing a much larger database for training and calibration. Gaming represents one potential way for achieving this. Games are currently the number one application used on smartphones [5], which represents an incredible number of potential players. Serious games, games with a purpose and gamification of existing applications are now becoming more common place [4, 13] so the idea of moving Geo-Wiki into a gaming environment was a logical step forward in encouraging citizens to participate. Previous serious games were tried with some success, e.g. [16], but we realised that a much simpler approach was needed.

This paper outlines the most recent development in the Geo-Wiki project, which is a game called Cropland Capture. The ultimate goal of the game is to gather training and validation data for improving global maps of cropland extent, which will be part of future research. The game is currently running and will end in May 2014. This paper outlines some initial results of the data gathered from the game and our plans for the future.

2 Cropland Capture

Cropland capture is a simple game in which players are presented with a red rectangle placed on top of satellite imagery from Google Earth. They are then asked to determine if there is any evidence of cropland in the image (Figure 1). They can answer yes, no or maybe if they are unsure. For each correct answer, the player receives a single point. For incorrect answers, the players lose one point. If a player answers maybe they do not gain or lose any points. We define correct answers in one of two ways. The first way involves expert intervention, where some of the pixels are 'control pixels', i.e. the answers have already been pre-determined by remote sensing experts. These pixels are taken to be the 'truth' and correctness is determined based on whether players agree

with the 'truth'. There are only a small number of control pixels in relation to the overall total pixels in the game.

The second way for determining correctness is through a 'majority rules' approach for those pixels where the answers are not known *a priori*. The first few times that a pixel is classified, the answer is always correct since a profile of answers must first be built up for each pixel. Correctness is then determined through agreement with the crowd at that point.

Figure 1: A screenshot from the Cropland Capture game.

The game will run for a total of 6 months from mid-November 2013 until May 2014 to provide a good compromise between collecting as much information as possible while still retaining participation. The incentives for participation are prizes awarded at the end of the game, which include smartphones and tablets. In order to be eligible for a prize, players must be included in the final draw for these prizes. To become part of the draw, players must be in the top three scores each week, where scores are reset to 0 on a weekly basis at midnight each Friday. Thus in total there will be 75 people in the final draw. Some individuals have made it into the top three more than once so they effectively increase their chances of winning the prizes at the end. Additional prizes will be offered during the last five weeks of game play to motivate additional participation.

The game was launched via a media campaign, with press releases, blogs and a twitter account set up for the game. From there, the game was picked up in a blog by National Public Radio, an article in the Guardian and reported with interviews by Geo-Wiki staff on German radio (Deutsche Welle) and Austrian media (ORF). All of these media outlets contacted us without any initiation by us. The Geo-Wiki network was also contacted, where we simultaneously launched a new monthly newsletter to provide regular updates on the game.

The game can be played online (see http://www.geo-wiki.org) or on an Apple or Android smartphone or tablet. The apps can be downloaded from the app stores for these devices.

Figure 2 shows the 'About Cropland Capture' screen, which provides some background to the game but also training materials. Players can view examples of cropland and land cover that is not cropland, which is useful for those players who have never viewed much satellite imagery before. There is also an FAQ, which contains answers to common questions that players have emailed us about.

Figure 2: The 'About Cropland Capture' screen.

Although not visible from Figure 1, the player's score will appear at the top and players can access a leaderboard to compare their progress against other players.

3 Initial Results

The location of the pixels is based on a global validation data set [18] at varying resolutions from 250m to 1km^2. We have also added in the locations at the Degrees of Confluence project (http://confluence.org). The dates associated with the imagery is recorded separately. The results presented here correspond to the data collected at around the halfway point of the game. At that point there were 2,817 players who contributed a total of 3,297,928 answers or image interpretations as part of playing the game. The same image was provided to many players as mentioned previously so there are currently 137,551 uniquely classified pixels of varying resolution. New pixels are always being added to the game.

Figure 3 shows the number of times that images have been classified multiple times. Roughly two-thirds of the images have been classified more than 5 times with one image having been classified more than 500 times.

Figure 3: The number of times that images have been classified multiple times

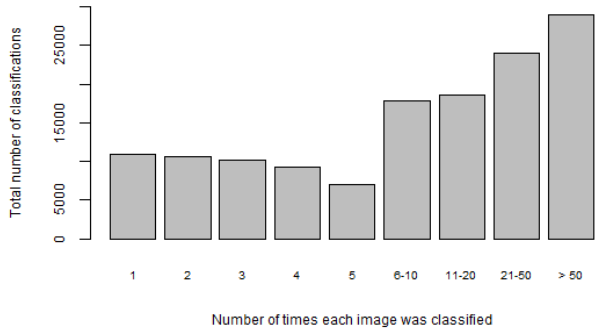


Figure 4 shows that the majority of images have a greater than 70% agreement between the players where only those images with more than 10 answers per image were included.

Figure 4: Example where agreement is less clear cut

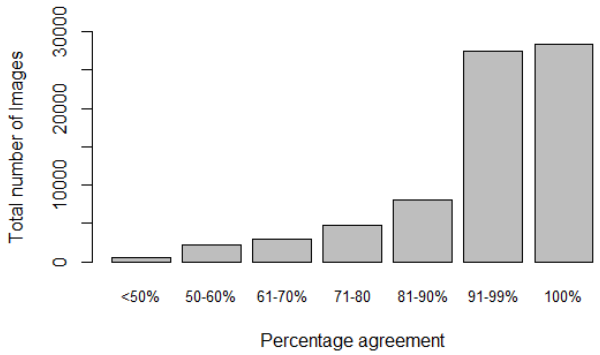


Figure 5 shows an example of high agreement on cropland. For this image 35 out of 36 players indicated cropland while 1 player said there was no evidence of cropland.

Figure 5: Example of cropland indicated 35 out of 36 times

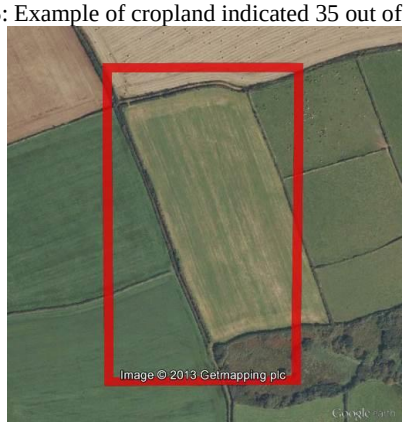


Figure 6, on the other hand, shows an example of an image where the players are split between cropland and non-cropland. Of the 59 evaluations for this image, 33 players said there was cropland, 25 said no cropland and 1 said maybe.

Figure 6: Example where agreement is less clear cut

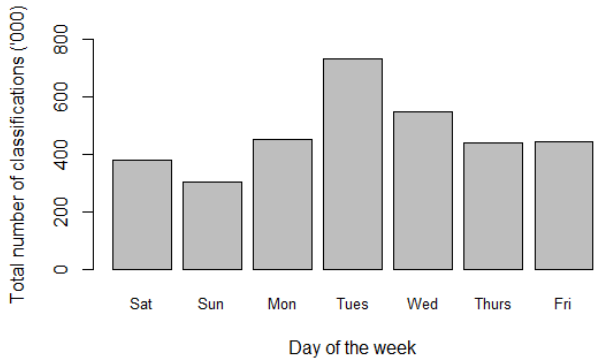
In this case the majority is still correct, i.e. there is cropland visible on the lower right hand side of the image.

Since the agreement with the crowd largely determines correctness (as outlined in section 2), a number of players contacted us about adding an option to disagree with the 'correct' answer provided. This option was added and is illustrated in Figure 7. For this image, 107 players said there was no evidence of cropland, 42 said cropland was present and 3 answered maybe. Using the majority rule, this image would contain no cropland as 'correct'. One of the players then disagreed with this answer and the image was automatically sent to an expert. The expert confirmed that cropland is present in the lower left corner of the image and the player who disagreed with the original answer of 'no cropland' was awarded extra points. This feature has now been used on various occasions to correct the answers provided by the crowd.

Figure 7: An example of an image contested by a player

There are many other analyses that are currently being undertaken with the data. A final example is provided regarding patterns of activity over the week. Since the competition scores are reset each week as explained in section 2, we expected the majority of activity to take place in the early part of the week, i.e. Saturday, Sunday and Monday as the players do battle for the top three positions early on during each week. However, as Figure 8 shows, this main activity occurs on Tuesdays and Wednesdays, which is counter to what we expected.

Figure 8: Number of classifications during the week



This type of temporal information could be used to provide a greater understanding of how incentives might affect player behavior over time.

4 Next Steps

We are currently in the process of analyzing the data for user performance, with the ultimate goal of developing simple rules that will determine the minimum number of classifications needed per pixel before we can be confident in the majority. Right now we have many pixels that have been classified more than 50 times yet it would be more efficient to remove pixels from the game when a minimum number has been reached, thereby allowing more areas to be classified. Right now the decision to remove pixels from the game is applied in an ad hoc basis but we are in the process of developing empirical rules for more efficient removal that are based on the results of the game so far. We will use these rules in future games.

Once the game is complete and the data filtered by quality, we plan to use the dataset for developing and validating a global hybrid cropland map where we will integrate many existing cropland products to produce a single, improved product. The data from the game will be used to help determine which product is correct at a given location and for validating the resulting map.

The success of the game so far means that we will use this type of approach for gathering other land cover types in the future.

Acknowledgements

EU COST Action TD1202 Mapping and the Citizen Sensor and the EU FP7 ERC Crowdland project.

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