Land cover validation game

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Abstract

Land cover data constitutes highly useful information to monitor the extension and status of land resources, hence it has been realized how important it is to have accurate land cover data. Here, an interactive WebGIS is built in order to validate GlobeLand30 global land cover data. The Game with a Purpose (GWAP) human-based computation technique is adopted. The system is based on crowdsourcing, i.e. multiple users play the game to validate land cover classifications, thus increasing the confidence level of the validation.

Keywords

Land cover validation, WebGIS, Game With A Purpose, Crowdsourcing.

1 Introduction

Land cover data represents very valuable resource for many different studies related to the environment and sustainable development. However, the usage of this data in many applications cannot disregard its validation and the knowledge of its classification accuracy. Among the land cover validation techniques, Web-based applications are growing increasingly. The approaches proposed by Fritz et al. (2009) and Bastin, Buchanan, Beresford, Pekel, and Duboi (2013) represent notable examples. Geo-Wiki (Fritz et al., 2009) is certainly one of the most popular applications used for validating global land cover using crowdsourcing. The disagreement maps between different global land cover products are provided, where users validate these products using Google Earth. In the application of Bastin et al. (2013), authorized users have to visually assess land cover and may provide uncertainties information at various levels: from a general rating of their confidence to a quantification of the proportions of land-cover types within a reference area.
The objective of this work is to develop an interactive WebGIS for the crowsourcing-based validation of GlobeLand30, a new global land cover dataset at 30 meters resolution derived from the classification of Landsat (TM and ETM+) and HJ-1 satellites images according to the pixel-object-knowledge-based (POK-based) approach (Chen et al., 2014). The dataset has been produced by the Chinese government and released as open data in September 2014. It is available for the two baseline years of 2000 and 2010.

Within a research study aimed to evaluate the classification quality of GlobeLand30 on the Italian area (Brovelli, Molinari, Hussein, Chen & Li, 2015), this dataset has been compared with more accurate Italian land cover maps. Results show a degree of disagreement that ranges between 10% and 20%. For the non-coherent data another level of validation is needed.
The implemented WebGIS is intended to involve citizens to classify the non-coherent pixels. In comparison to Geo-Wiki, which makes use of Google Earth in its Web application for the validation purpose, we implemented a Web application which makes use of high resolution aerial photos in the form of a gaming environment which may attract many more citizens for the validation process. Currently, the area of Como municipality (Lombardy, Italy) has been considered for the WebGIS implementation.
In the following sections the classification quality of GlobeLand30 in Como region, the developed WebGIS characteristics and the implemented gaming approach are presented.

2 GlobeLand30 accuracy on Como areas

The assessment of classification accuracy of GlobeLand30 on the Como municipality area has been calculated by means of a comparison with DUSAF ("Destinazione d'Uso dei Suoli Agricoli e Forestali"), the Italian acronym for "Use Categories of Agricultural and Forest Soil" (Credali et al., 2011), the land cover data from Lombardy Region at scale 1:10'000. DUSAF is periodically updated through aerial photo interpretation integrated with regional databases information and it is currently available in five releases. Among these, the datasets referred to years 2000 and 2012 were selected for comparison with GlobeLand30 2000 and GlobeLand30 2010, respectively.
To enable the comparison, both datasets have been reclassified according to the first level of Corine Land Cover nomenclature, i.e. the hierarchical thematic legend adopted by DUSAF. As shown in Table 1, the degrees of disagreement between the datasets are coherent with those reported by Brovelli et al. (2015). The number of non-coherent pixels for the years 2000 and 2010 on which the validation process will be applied is equal to 17'773 and 18'510, respectively. Each pixel size is 30×30 m.

	Coherent pixels	**Non-coherent pixels**	**Overall Accuracy [%]**	**Disagreement [%]**
2000	66'701	17'773	79	21
2010	65'955	18'510	78	22

Table 1 - Comparison between GlobeLand30 and DUSAF on Como area: number of coherent/non-coherent pixels, overall accuracy and degree of disagreement.

The spatial distribution of non-coherent pixels (Figure 1) has been obtained by computing the difference between the compared datasets. These pixels will be validated by means of aerial photos at 0.5 m resolution provided by Blom CGR S.p.a. (http://www.blomasa.com/home.html)

Figure 1 - Distribution of non-coherent pixels (red areas) in the Como municipality area for year 2010.

3 WebGIS

A dynamic Web application was built which targets on crowdsourcing to validate the land cover dataset. Here PostGIS database has been integrated with Geoserver in order to store the aerial photos and other data. These data are made available via Web Map Service (WMS) in a browser-based interface by means of Angular JavaScript, Leaflet JavaScript library and server-side PHP code. The WebGIS consists of three panels, namely map panel, title panel and side panel. The pixel to be validated with aerial photo and five classification options are displayed in the map panel. The title panel is provided with a *Leaderboard* tab which displays the top three player positions and the player position of the current user, a *Best last Players* tab which shows the best players list according to the cumulative score achieved during the last ten game rounds, a *Badge list* tab which shows the list of badges that the player could win during the game play according to his performance, a *How to play* tab which shows a popup with instructions on how to play the game. The side panel consists of time counter, score board and the badge list.
The validation of land cover accounts for two different years (2000 and 2010). Two separate WebGIS were built for the years 2000 and 2010, respectively. In each of them non-coherent pixels (one at a time) are displayed to the user who has to choose a classification for them (Figure 2). Each non-coherent pixel is extracted randomly without following particular order. After submission of each answer, the user is displayed with another non-coherent pixel. The user is freely allowed to pan and zoom the map in order to correctly identify the pixel classification.

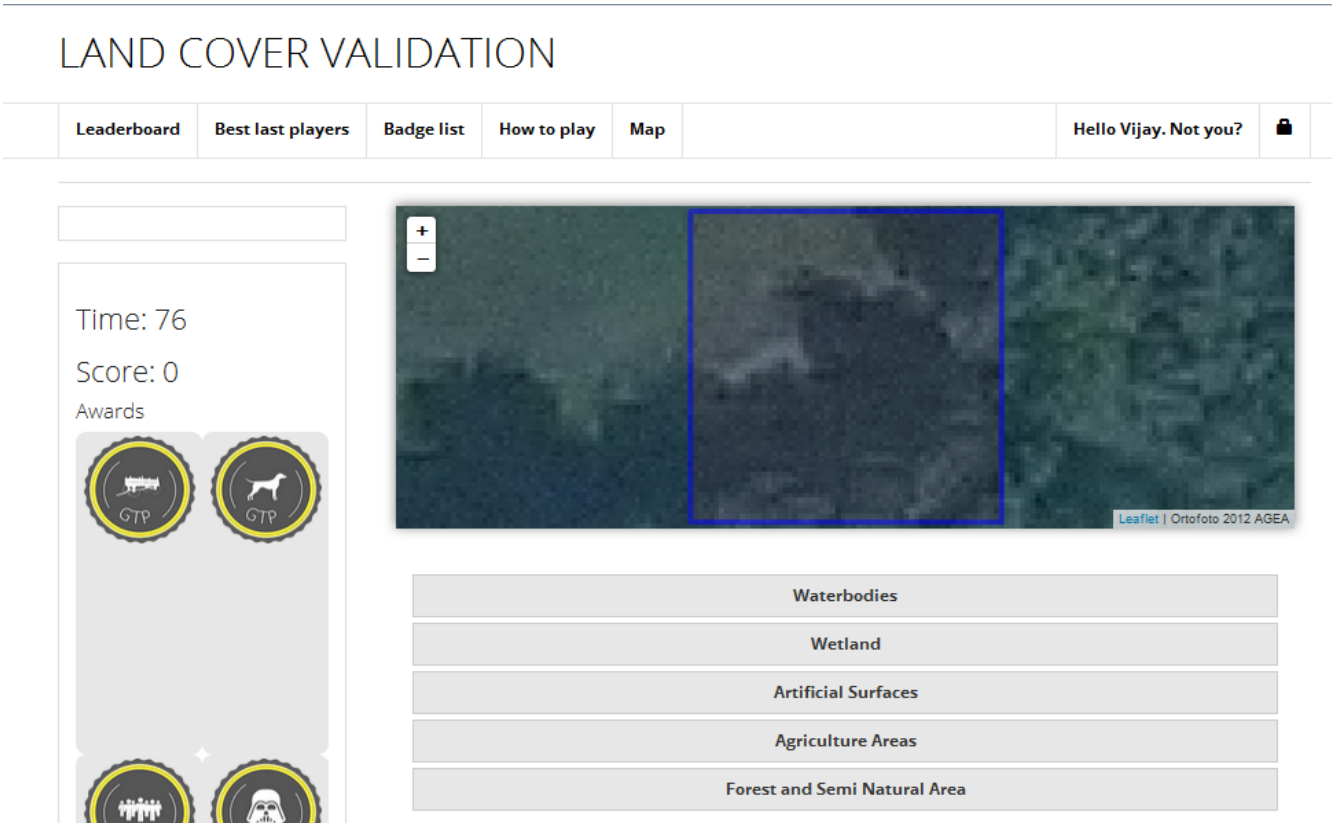

Figure 2 - Interactive Web application which displays a pixel (blue square box) for which user chooses a classification.

4 Gaming

The WebGIS is incorporated within a Game with a Purpose (GWAP) application, in line with the original proposal by Von Ahn (2006). A GWAP is a Human Computation application that puts a task in a crowdsourcing environment with a gaming flavor; the GWAP player has fun playing the game and, as a collateral effect, solves the Human Computation task. Here the purpose incorporated in our GWAP is land cover validation. This interactive game will engage the users to classify aerial images for their land use; as a consequence, the game will increase the quality of the land cover classification. For each pixel, the system knows the classified land use according to DUSAF and to GlobeLand30, which can be considered the “expert’s answers”; if the GWAP player’s answer matches an expert answer, the player will score a point in the game and will have fun. As incentives for the users to continue playing, we provide two mechanisms: on the one hand each game round gives some points, so a leader board is built to let the players compare their performance with other players; on the other hand, specific answer combinations assign players with badges that are aimed to make the game more attractive. Meanwhile, the system will collect the answers from multiple players; by cross-checking those players’ answers, the global land cover map will be validated by increasing the confidence about the correctness of the most “popular” answer.

5 Conclusions

The land cover validation game is a novel interactive system that allows citizen scientists to validate land cover maps while having fun. This game gives the right classification with a high level of confidence. This work is targeted at people who have a basic level of knowledge in image interpretation. Our purpose is to demonstrate that validation process could be increased by crowdsourcing. This game is a work in progress and we are currently studying how to assign proper scores to the players according to choices made on different land cover classifications. User information collected from this game will be stored in the database for further statistical evaluation to obtain the confidence level of the GlobeLand30 dataset.

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