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A new method for perceiving origins of international important Ramsar wetland ecological habitat scenes in China

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ABSTRACT

A tentative and interesting experiment was conducted for perceiving the origins of international important Ramsar wetland ecological habitat scenes (WEHS) in China. Four different categories of international importance wetlands in the Ramsar list, including DongZhai Harbor inter-tidal mangrove wetland in Hainan Province, Lashi Lake alpine peat wetland in Yunnan Province, Zoige plateau freshwater lake wetland in Sichuan Province and Yancheng coastal saline wetland in Jiangsu Province, in China were investigated. The spatial envelope (SE) algorithm was used to extract the ecological features of the WEHS. The multi-resolution spectral functions of the SE algorithm in the spatial-frequency domain were rearranged to be approximately orthogonal. The original ecological image was transferred through such optimized channels and some valid features were obtained, which can be used to represent the WEHS. The principal component analysis algorithm was used to extract the principal components from these optimum characteristics. Three kinds of nonlinear recognition methods including conditional maximum entropy regression, multi-class support vector machine (SVM) and scaled conjugate gradient multi-layer perceptron were used to determine the logical ecological habitat attributions using the obtained principal components. The first-ranking perceiving accuracy and mean average precision (mAP) scores achieved 70% and 0.791 by using the multi-class SVM, respectively. The results demonstrated that the proposed methods could be preliminarily used to perceive the origins of the typical WEHS in China.

1. Introduction

Wetland is the homeland for harmonious coexistence of man and nature. Wetland plays a number of roles in the environment, principally water purification, flood control, and shoreline stability, etc. (Zhang and Song, 2014). Wetland is also considered as the most biologically diversity of all ecosystems, serving as home to a wide range of plant and animal life (Bassi et al., 2014). Wetland is covering a total area of 6600 million ha in China's territory. The regions account for more than 10% of the China world's and ranks first in Asia (Yin and Yin, 2010). Thereby, the study and conversation of ecological environment, balance and biological diversity of China's wetland ecosystems will make a marked impact on the global ecosystems (Lu and Jiang, 2004). Despite their enormous ecosystem functions, wetlands have been threatened by the rapid growth of social economics during recent decades all over the world (Sun et al., 2015). Currently ecological factors of wetlands, such as water quality (Zhang et al., 2012), biological community structure (Tang et al., 2013), physical and chemical properties of soil (Gao et al., 2013), had been changed dramatically. The investigation of perceiving the origins of the wetland ecological habitat scenes (WEHS) is available for providing a novel kind of scientific means for evaluating the changes of wetland species and environment (William et al., 2002), determining the layouts of ecological protection zones (An and Wang, 2014) and restricting the remoulding activities of humans in the wetland ecological regions (Tousignant et al., 2010). As far as we know, the relevant scientific research is not progressing well, few documents are available and less experience can be borrowed. The main constraint on its development should be due to the complexities and diversities of ecological factors, which gives rise to difficulty to promote the development of such investigations and disciplines (Balázs et al., 2015). However, the wetland ecosystem habitat conservation and sustainable development closely concern the daily life and production of all living beings (Sheng et al., 2012), so more attentions should be paid to the development of this specific research work.

In order to realize the perceiving function of the WEHS, the first step is to obtain the valid features to represent the WEHS. Alvarez and Oliva (2008) presented a spatial envelope (SE) model to encode

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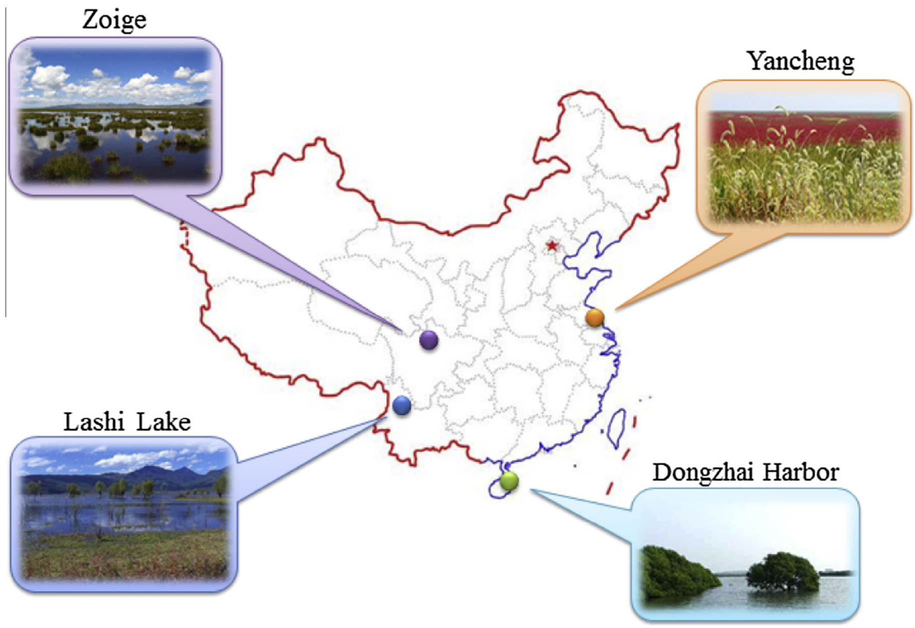

Fig. 1. A diagram of geographical distribution of four distinct categories of international important WEHS including DongZhai Harbor wetland in Hainan Province, Lashi Lake wetland in Yunnan Province, Zoige wetland in Sichuan Province and Yancheng wetland in Jiangsu Province, in China.

the natural scenes and urban environments. The classical SE algorithm employed 2D-Gabor functions to obtain the multi-scale features. Such 2D-Gabor peaks were apt to overlap, which caused that some detail feature information might be covered in the overlapping spectral bands (Zhao et al., 2011). The masked feature information would influence the performance of scene representation. In this paper, the novel approximate orthogonal spectral functions are proposed to configure the SE algorithm in order to reduce the amount of overlapping regions.

In most literatures, the scopes of scene recognition were limited by the obviously different semantic categories, e.g. indoor and outdoor scenes (Espinace et al., 2010), urban and suburban scenes (Li and Itti, 2011), city and village scenes (Szeliski et al., 2007), but seldom focus on the wetland varieties. In our study, the objects of recognition scenes were merely related to the wetlands. The instances in our research included DongZhai Harbor (DZH) intertidal mangrove wetland in Hainan Province (Xin et al., 2014), Lashi Lake (LSL) alpine peat wetland in Yunnan Province (Voeller, 2011), Zoige plateau freshwater lake wetland in Sichuan Province (Xiao et al., 2010) and Yancheng (YC) coastal saline wetland in Jiangsu Province (Ke et al., 2011), in China. A diagram of geographical distribution of these four different types of wetlands was illustrated in Fig. 1. These places were all included in the Ramsar List of international important wetlands (Hettiarachchi et al., 2015). These WEHS were composed of the extremely similar ecological elements and textures. As far as we know, the research work of perceiving such complex and diverse ecological environment has not been reported.

The specific aims of this study were to (1) develop a novel SE algorithm with approximate orthogonal configuration of spectral functions in order to obtain more detailed features from a scene, (2) evaluate the feasibility of using artificial intelligence (AI) techniques for perceiving the origins of the typical WEHS, and (3) helpfully provide a novel means for understanding the habitat structures and changes of wetland ecosystems.

2. Experimental data

The database of WEHS consisted of four classes of typical instances including DZH inter-tidal mangrove wetland in Hainan Province, LSL alpine peat wetland in Yunnan Province, Zoige plateau freshwater lake wetland in Sichuan Province and YC coastal saline wetland in Jiangsu Province, in China. Some important ecological habitat attributes describing these four types of wetlands were summarized in Table 1. The attributes were closely related to our study and directly determined the compositions of captured scene images. These WEHS pictures were taken from the digital cameras. The captured work was carried out in daytime (7:00 a.m.–5:00 p.m.) when the sun light was sufficient. There was actually a vast absolute distance between the observer and the fixated WEHS, usually greater than 6 m. The real distance and the aperture of the cameras were varied for the used images. Most of the images were in focus and with realistic colors, thereby, there were not any blur images used for measurements. All the WHES images were firstly resized to (250–600) × (250–600) pixels in size before analysis. The colors were not taken into account in this study and transformed to the gray scale of 8 bits as following (Wang and Liew, 2007):

$$gray = 0.2989R + 0.5870G + 0.1140B \quad (1)$$

where R, G and B denote the intensity values in the red, green and blue channels in 256 levels, respectively. There are a total 1200 images of the WEHS in the database, where each variety has 300 images. For learning the relationship between the SE feature variables and the corresponding logical habitat attributes, we utilize 240 and 60 images for both modeling and derivation purposes for each group, respectively.

3. Theory and approaches

Firstly, the algorithm of approximate orthogonal configuration of spectral functions is presented in Section 3.1, and the algorithm of spectral and coarsely localized information used to represent the dominant spatial structure of the WEHS is described in Section 3.2. Three kinds of nonlinear learning algorithms including conditional maximum entropy regression (CMER) (Yu et al., 2011), multi-class support vector machine (SVM) (Chang and Lin, 2011) and scaled conjugate gradient (SCG) multilayer perceptron (MLP) (Du and