Methodology for Automatic Observation of sky patterns

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Abstract. *Surface observers on monitoring meteorological stations regularly classify and register sky patterns based on human cognitive training. Substitute those observers by automatic systems is highly desirable to reduce subjective analysis. Most automatic systems use thresholding methods and ignores other physical phenomena existent in atmosphere obtaining only binary results (clouds and sky). The current work proposes a method that will establish the correspondence between observations percept from those patterns and theory using Bayesian approach embedded in Intelligent Agents in the following steps. Model the cognitive patterns on color space obtained from surface cameras and analysis. Validation and refinement of system results could be done using sun photometers and LIDAR systems.*

Keywords: Automatic pattern recognition, Cognitive Bayesian model, Multivariate statistics, atmospheric patterns.

1. Introduction

The main purpose of the current work is the characterization of sky patterns on Celestial Hemisphere (CH) observable from the surface. This characterization will improve the classification and qualification of observed optical atmospheric phenomena allowing the use of intelligent agents (IA) (NORVIG and RUSSEL, 2003). The most widely used characterization of sky patterns present on CH is established by World Meteorological Organization WMO. Synoptic observers use WMO (1975, 1987 and 1996) criteria to classify cloud type, height and amount according current atmospheric conditions. The human observer is intended to be replaced from that task by a surface camera equipped with "fish eye" lens and image interpretation algorithms, reducing efforts imposed by regular human working shifts, subjective aspects and misinterpretation. Sky monitoring by cameras and related methods are also a part of the efforts to environment monitoring activities (WCRP Report 2007). The automatic sky imagers available on the market usually presents binary evaluation of CH patterns (sky and clouds), reducing the dimension of color space restricting the capabilities present on observed color domain (LONG et al., 2006). WMO classification was established to be used by an observer that has a very well developed and trained cognitive system to watch, classify and register the CH patterns. The synoptic observer has a good performance on qualitative analysis and poor performance on quantitative of the present CH conditions. With automatic systems is the inverse. The defined rules established by WMO are not suitable to be used by IA to replace human observation. With current paradigms IA are not capable yet to fully classify different patterns from those ones defined on the WMO domain environment[1]. If the domain is restricted, so is the program analysis or IA action. The classification criteria established by WMO could be used as a target objective for IA classification, but not as a domain. The sensed domain to be considered in that case is broader than cloud observation parameters established by WMO, leading IA´s to misinterpretation. This misinterpretation increases the uncertainty of the observation and imposes a disappointment on automatic systems outcomes. The current work will show that WMO standards are not suitable to be used as a domain environment, but as a target outcome. It proposes an alternative domain based on optical atmospheric phenomena percept by humans to be used by IA. To achieve that an exploratory data analysis (EDA) is proposed to be performed in color space to find atmospheric patterns typical locus on a multivariate context. As the pattern identification is highly oriented to human interpretation, cognitive modeling using a Bayesian approach (supervised learning and analysis) related tools is intended to be performed. To validate the aforementioned model a field experiment is also proposed to validate and refine the proposed patterns analysis using LIDARS and SUNPHOTOMETERS. The next sections presents a little further details about the proposed method.

2. Cognitive Environment Definition and Physical Context

Proper environment definition is a key issue in the current work. The environment will be defined according to the work proposed by Newell & Simon (1972). In that work it is suggested the definition of three different levels to be taken into account by the IA: research, task and problem environments. Restrictions on those environments could lead to inaccessible states on the problem solution (MANTELLI, 2001). The current studies consider only the visible part of radiation, because sensor and human cognitive systems only respond to visible part of the electromagnetic spectrum. Two principal physical phenomena dominate the interaction of sun light with the atmosphere, scattering and absorption (LILLESAND and KIEFER, 1994; LENOBLE, 1993; IQBAL, 1984). The principal observable scatter causes are: Rayleigh, Mie, aerosol atmospheric turbidity, non selective and sun light diffusion. The principal observable effect of absorption is the dark and grey levels of clouds. More detailed information about proposed environment could be observed on figure 1. In this context an EDA of those patterns on multivariate color space need to be performed to characterize their typical locus.

[1] Domain is a section of the world about which we wish to express some knowledge. P. 197 (RUSSEL AND NORVIG 2003).

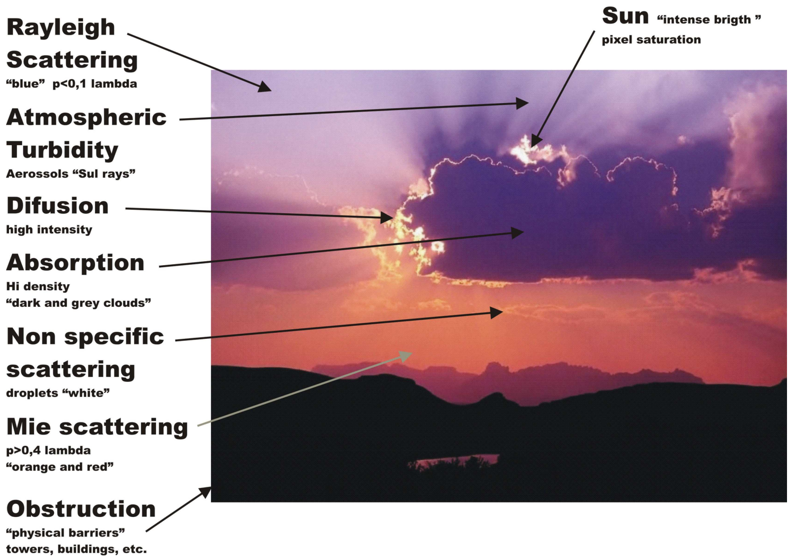

Figure 1. A typical scenario of proposed observable sky patterns from surface.

Categorization of clouds according to WMO is also an issue to be deal with. It is a point to be investigated that clouds could be discriminated by texture. It is considered that cloud texture is the same but different altitudes of same texture causes different properties that could be distinguished. Fourier analysis, wavelets and similar methods is intended to be used to investigate that. From physical context above several patterns may be proposed to take part on the environment and could be easily identified by its results. If not defined properly automatic systems are far behind to percept patterns properly. Task environment defined that way is further beyond WMO standards. The first suggestion is to reduce the identified patterns and map into a WMO goal as suggested on physical context. The difference now is that mapping is done specifically by the system and not unpredictably and improperly by the software.

3. State-of-the art and future work

Based on the aforementioned reasons it was proposed an environment defined by induction using Bayesian cognitive modeling (TENENBAUM, 2006). In that context current research leaded to multivariate statistical exploratory data analysis (EDA) of proposed image patterns. Although the current research is working in EDA definition the appropriate IA inference still have to be defined. The model validation is proposed in two steps. The first step is comparing the system performance against a synoptic observer. The second one, by using advanced field equipments and atmospheric modeling. Among then it is proposed a sun photometer and a LIDAR[2] techniques to measure simultaneous atmospheric and visual parameters such as clouds distances by texture.

4. International cooperation and French-Brazilian teams

The state-of-the-art of sky imaging is being addressed by several research institutes and is being targeted by international scientific community (WCRP Report 2007). The

[2] LIDAR – Laser Detection and Ranging.

original approach and modeling could be done in a joint cooperation between Brazil and France. Several INRIA Research groups could be involved in these tasks.

The first one in formal modeling, representation and interpretation of sky patterns into its symbolic atmospheric meaning. Checking if the proposed method is the more appropriate to be applied on the specific cognitive area. The effects of image illumination variation along the day should also be investigated. (INRIAS's PERCEPTION research group)

The second one is the model selection and statistical learning for pattern recognition in the multivariate image domain of the atmospheric patterns. Patterns should be investigated for their typical distribution (normal or non-normal) on color space. The study could be extended by adding and verifying the effects (or factors) of typical solar variables (global, direct and diffuse) on image. (INRIAS's SELECT research group)

The third potential research group could be on model validation. Validation could be done in several ways. It will be proposed two methods. The first one demands high cost equipments not available to the Brazilian counterpart (i.e. sun photometers, trackers and LIDARS) or satellite images. Some of these manufacturers are based in France (CIMEL), and are present in several French research centers. For satellite images INRIA has a research group working on environment data processing and computer vision techniques (INRIAS's CLIME research group).

5. Expected Scientific results

Several results are expected from current research as listed. Development of a suitable IA in applied area. An improvement of automatic sky imaging observation methodology to be employed on surface monitoring stations. Cost reduction and rationalization of current synoptic operations. Test of a suitable monitoring point for cross validation of satellite images on visible spectrum for clear, cloudy and mixed conditions skies. A better evaluation of atmospheric models on mixed cloudy conditions. A comparison of proposed methodologies based on tropical and tempered climates.

6. Collaboration proposals.

Actually UFSC-INE-LAPIX (Laboratory of Image Processing) do not have cooperation program with any official INRIA partners. Current potential Brazilian Partners includes INPE-CPTEC (Brazilian Institute for Space Research – Center of Weather Forecasts and Environment Studies). The proposed activities for Brazilian partners involve modeling of domain and target sky patterns. Joint affords could be done with PERCEPTION and SELECT groups on cognitive aspects of synoptic observation and statistics modeling. CLIME group could support on validation and atmospheric physics issues of atmospheric modeling. The proposed activities with INRIA partners involve modeling and operational support for field validation of proposed modeling.

7. Conclusions

Although Celestial Hemisphere pattern classification has a satisfactory result when done by a trained operator, automatic classification using surface cameras are subject to uncertainties due to inappropriate approach. Current work proposes a new paradigm on classification matching physical and optical phenomena based on current atmospheric conditions. This approach is believed to open a new perspective based on human cognitive observations to automatic systems. Once the factors that cause uncertainties are tagged, it is easier to be addressed and overcome them. Independently of the **how** the solution will be implemented **what** to do to solve the problem is now established. Define which intelligent agent to do the job and the best technique to solve it is the next step. The new approach presented here is believed to be a suitable approach for classification of Celestial Hemisphere patterns.

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