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Pattern Recognition And Image Processing : A Study

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ABSTRACT

Computer Vision is a very active research field with many practical applications, for instance in quality control, robotics, or driving assistance systems. The ultimate goal of Computer Vision is to imitate the capabilies of the human visual system, allowing the computer not only to record images but also to interpret them. Research has made significant progress in recent years and particularly deep learning has helped improve on many tasks and approach new ones. In this seminar we will take a detailed look at some of the most interesting recent works. For each paper there will be one person, who performs a more detailed investigation of a research paper and its background and who will give a presentation. The presentation is followed by a discussion with all participants about the merits and limitations of the respective paper. You will learn to read and understand contemporary research papers, to give a good oral presentation, to ask questions, and to openly discuss a research problem. In this paper, based on image processing of intelligent building as the basic theoretical platform, with the pattern recognition technology as the basic research means, three problems of image processing, image extraction and image recognition in image processing of building intelligent environment are studied respectively, and corresponding reasonable solutions are put forward.

Keywords:Image classification,Pattern recognition, Image segmentation,Image Restoration.

INTRODUCTION

Image classification is the process of creating a thematic image where each pixel is assigned a number representing a class (can include the class 'unclassified'). In an aerial image the classes can be soil, vegetation, water etc. image classification algorithms examples are k-means or ISO-DATA. **Pattern recognition** is the process of finding **things** in an image, for example, search for tanks in an aerial/satellite military image or search for a cancerous cells in a medical image or a garden surrounded by buildings or face recognition. usually this will include specific logic about the pattern you want to find. Most image analysis algorithms are pixel based. However, a major drawback of pixel based algorithms (by definition) is that they do not take contextual information into consideration (context in this case is used to describe the relationship between a pixel/object and its environment). A possible solution to the problems of pixel based image analysis is to operate in the spatial scale of the objects of interest. Object based image analysis (OBIA) is a science field dedicated to dividing images to meaningful image-objects and evaluating their characteristics in the spatial, spectral and temporal aspects.**Image segmentation** is a process of aggregating neighboring pixels into objects (regions, segments), such that every object is homogeneous (relative to a certain homogeneous criterion e.g texture), but union of two neighboring objects is not homogeneous. Image segmentation algorithms examples are Watershed, and various edge based, region growing

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Vol-22-Issue-10-November-2019

and split and merge algorithms. this is the place to mention that there is no best image segmentation as it is subjective. give several people to segment an image and you'll have several different segmentation (similar probably but not the same). i think this is the case for allot of image processing algorithms

IMAGE RECOGNITION

Image recognition or a computer vision is a technical discipline that deals with searching the ways to automate all the job that a human visual system can do. Tensor Flow by Google, Deep Face by Facebook, Project Oxford by Microsoft are great examples of deep learning image recognition systems. On the other hand, hosted APIs such as Google Cloud Vision, Clarifai, Imagga allow businesses to save some money on the costly computer vision development teams. Advantages of open-source services mentioned are numerous. They conduct image recognition computing in the cloud making your imagetech business operations more efficient and much cheaper. Also in-house developers at your company can integrate their APIs into your apps without problems. Moreover, these open APIs developers can use to even start a new business in the field of image recognition.

IMAGE PROCESSING TECHNIQUES

Generally image processing consists of several stages: image import, analysis, manipulation and image output. There are two methods of image processing: digital and analogue. In particular, digital image processing and its techniques is what this article is about. Computer algorithms play a crucial role in digital image processing. Developers use multiple algorithms to solve different tasks, including digital image detection, analysis, reconstruction, restoration, image data compression, image enhancement, image estimation and image spectral estimation.

Major techniques of digital image processing are as follows:

- **Image Editing**, which basically means altering digital images by means of graphic software tools.
- **Image Restoration**, which refers to the estimation of a clean original image out of the corrupt image taken in order to get back the information lost.
- **Independent Component Analysis**, which separates a multivariate signal computationally into additive subcomponents.
- **Anisotropic Diffusion**, which is often known as Perona-Malik Diffusion, makes it possible to reduce image noise without having to remove important parts of the image.
- **Linear Filtering**. It’s another digital image processing technique, which refers to processing time-varying input signals and producing output signals that are subject to the constraint of linearity.
- **Neural Networks**, which are computational models widely used in machine learning for solving various tasks.
- **Pixelation**, which often refers to turning printed images into digitized ones (such as GIF).

ISSN:0971-1260

Vol-22-Issue-10-November-2019

- **Principal Components Analysis**, a digital image processing technique that can be used for feature extraction.
- **Partial Differential Equations**, which also is dealing with effectively de-noising images.
- **Hidden Markov Models**, a technique used for image analysis in two dimensions.
- **Wavelets**, which stands for a mathematical function that's used in image compression.
- **Self-organizing Maps**, a digital image processing technique for classifying images into a number of classes.

HOW ADORIASOFT APPLIES IMAGE PROCESSING TECHNIQUES

Over the years Adoriasoft has implemented image processing techniques in multiple projects, including e-commerce web and mobile apps for its clients. For one of its major customers we created an object recognition tool called Object Mask. Developed in Delphi, the app creates a mask of an object. Thus e-commerce website users and those of mCommerce apps can see all relevant items in their search for similar goods. In addition, our clients may leverage the technology behind the app to the maximum extent and benefit from their clients' repetitive purchases. Speaking about more projects on image processing and image recognition Adoriasoft has also developed Duplicate Photo Cleaner for another its client. The technology implemented in the software compares all images on the PC or Mac system of a user and locates duplicate images. According to the manually set duplicate threshold (of up to 100%) the app is able to find exact or partially duplicated images. Using grayscale comparison feature users are able to locate duplicate photos among their black and white photo collection.

Adoriasoft has a profound expertise working with images and visual data processing using top libraries, tools and frameworks. Thus our team of developers and UX designers are well-versed in, but not limited to:

- working with all common image formats, including RAW, TIFF, HD Photo files, as well as XMP and EXIF fields;
- manipulating PSD layers, as well all kinds of image processing such as rotation, cropping, auto-cropping, perspective adjustment, flipping, zoom, resizing;
- applying multiple image effects and filters;
- acquiring images and video from cameras, scanners, portable devices that are WIA and Twain compatible;
- using all known selection types and color adjustment facilities;
- detecting skew and edge;
- removing red-eye and chromakey background;
- converting color ranges and much more.

PATTERN RECOGNITION

Pattern Recognition is the process of distinguishing and segmenting data according to set criteria or by common elements, which is performed by special algorithms. Since pattern recognition enables

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Vol-22-Issue-10-November-2019

learning per se and room for further improvement, it is one of the integral elements of machine learning technology. Christopher Bishop in his seminal work "Pattern Recognition and Machine Learning" describes the concept like this: "*...pattern recognition deals with the automatic discovery of regularities in data through the use of computer algorithms and with the use of these regularities to take actions such as classifying the data into different categories.*"

In other words, pattern recognition is identifying things by its features. These patterns tell the data stories through ebbs and flows, spikes and flat lines.

The data itself can be anything:

- Text
- Images
- Sounds
- Sentiments, and other.

Any information of the sequential nature can be processed by pattern recognition algorithms, making the sequences comprehensible and enabling its practical use.

PATTERN RECOGNITION MODELS

There are three **main models** of pattern recognition:

- **Statistical:** to identify where specific piece belongs (for example, whether it is a cake or not). This model uses supervised machine learning;

1. **Syntactic / Structural:** to define a more complex relationship between elements (for example, parts of speech). This model uses semi-supervised machine learning;
2. **Template Matching:** to match the object's features with the predefined template and identify the object by proxy. One of the uses of such model is plagiarism checking.

HOW DOES PATTERN RECOGNITION WORK?

While the majority of the AI Pattern Recognition operation is self-descriptive, there is a lot going on underneath.

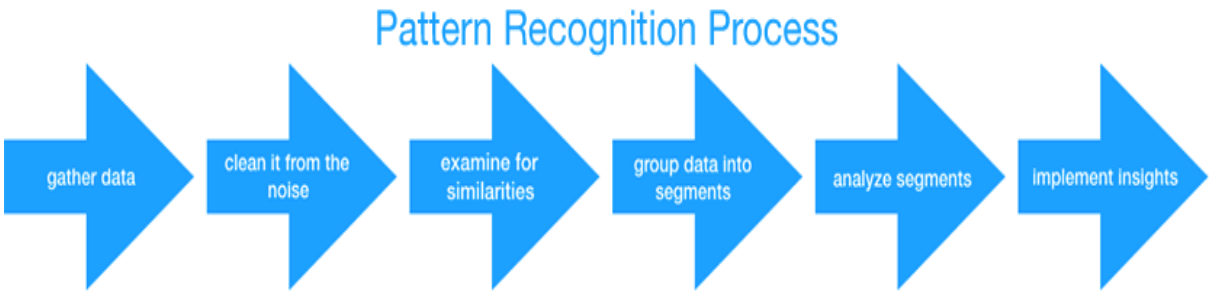
Overall, there are two major parts of pattern recognition algorithms:

- explorative - used to recognize commonalities in the data;
- descriptive - used to categorize the commonalities in a certain manner;

ISSN:0971-1260

Vol-22-Issue-10-November-2019

The combination of these two elements is used to extract insights out of the data, including the use in big data analytics. The analysis of the common factors and their correlation uncovers details in the subject matter that may be critical in the understanding it.



The process itself looks like this:

1. Data is gathered from its sources (via tracking or input)
2. Data is cleaned up from noise
3. Information is examined for relevant features or common elements
4. These elements are subsequently grouped in specific segments;
5. The segments are analyzed for insights into data sets;
6. The extracted insights are implemented into the business operation.

STOCK MARKET FORECASTING, AUDIENCE RESEARCH - DATA ANALYTICS

Pattern Recognition technology and Data Analytics are interconnected to the point of confusion between the two. An excellent example of this issue is stock market pattern recognition software, which is actually an analytics tool.

In the context of data analytics, pattern recognition is used to describe data, show its distinct features (i.e., the patterns itself) and put it into a broader context. (Read more about it in our article about Data Analytics.)

Let's look at two prominent use cases:

- **Stock market forecasting** - pattern recognition is used for comparative analysis of the stock exchanges and predictions of the possible outcomes. YardCharts use this pattern recognition analysis.
- **Audience research** - pattern recognition refers to analyzing available user data and segmenting it by selected features. Google Analytics provides these features.

THINK INDIA JOURNAL

ISSN:0971-1260

Vol-22-Issue-10-November-2019

TEXT GENERATION, TEXT ANALYSIS, TEXT TRANSLATION, CHATBOTS - NATURAL LANGUAGE PROCESSING

Natural Language Processing (aka NLP) is a field of Machine Learning focused on teaching machines to comprehend human language and generate its messages. While it sounds like hard sci-fi, in reality, it doesn't deal with the substance of communication (i.e., reading between the lines) - it only deals with what is directly expressed in the message.NLP breaks the text to pieces, finds the connections and then constructs its variation. The process starts with differentiating the sentences; then it sorts out the words and parts of the speech where they belong and finally defines the ways these words can be used in a sentence. To do that, NLP uses a combination of techniques that includes parsing, segmentation, and tagging to construct a model upon which the proceedings are handled. Supervised and unsupervised machine learning algorithms are involved in this process at various stages.

NLP is used in such fields as:

- **Text analysis** - for content categorization, topic discovery and modeling (content marketing tools like Buzzsumo use this technique);
- **Plagiarism detection** - a variation of text analysis focused on a comparative study of the text with the assistance of the web crawler. The words are broken down to tokens that are checked for matches elsewhere. The exemplary tool for this is Copyscape.
- **Text summarization and contextual extraction** - finding the meaning of the text. There are many online tools for this task, for example, Text Summarizer;
- **Text generation** - for chatbots and AI Assistants or automated content generation (for example, auto-generated emails, Twitterbot updates, etc.);
- **Text translation** - in addition to text analysis and word substitution, the engine also uses a combination of context and sentiment analysis to make closer matching recreation of the message in the other language. The most prominent example is Google Translate;
- **Text correction and adaptation** - in addition to correcting grammar and formal mistakes, this technique can be used for the simplification of the text - from the structure to the choice of words. Grammarly, a startup founded by two Ukrainians in Kyiv, Ukraine, is one of the most prominent examples of such NLP pattern recognition uses.

THINK INDIA JOURNAL

ISSN:0971-1260

Vol-22-Issue-10-November-2019

DOCUMENT CLASSIFICATION AND SIGNATURE VERIFICATION - OPTICAL CHARACTER RECOGNITION

Optical Character Recognition (aka OCR) refers to analysis and subsequent conversion of the images considered as alphanumeric text into the machine-encoded text.The most common source of the optical characters are scanned documents or photographs, but the thing can also be used on computer-generated unlabeled images. Either way, the OCR algorithm applies a library of patterns and compares them with the available input document to mark up the text and construct these. These matches are then assessed with the assistance language corpus and thus perform the "recognition" itself.

In the heart of OCR is a combination of pattern recognition and comparative algorithms attached to the reference database.

The most common uses of OCR include:

- **Text Transcription** is the most basic process. The text is presented in recognizable characters is recognized and transposed into the digital space. This technology is well-presented on the market. A good example might be ABBYY Fine Reader.
- **Handwriting Recognition** is a variation of text transcription with a more significant emphasis on the visual element. However, this time, the OCR algorithm uses a comparative engine to process the handwriting sample. A good example of this is Google Handwriting Input. While this technique's primary goal is to the transcript, it is also used to verify signature and other handwriting samples (for example, for signing contracts or handwritten will);
- **Document Classification** involves deeper processing of the document with a bigger focus on its structure and format. This technique is used for digitization of the paper of the paper documents and also for the reconstruction of the scattered elements of the damaged documents (for example, if the thing is shredded or the ink is partially blurred). Parascript is a product that provides such services for document classification.

THINK INDIA JOURNAL

ISSN:0971-1260

Vol-22-Issue-10-November-2019

VISUAL SEARCH, FACE RECOGNITION - IMAGE PATTERN RECOGNITION

Image Recognition is a variation of OCR aimed at understanding what is on the picture. In contrast with OCR, image recognition to recognize what is depicted on the input images during the image processing. Basically, instead of "recognizing" is "describes" the picture so that it would be searchable and comparable with the other images.

The main algorithms at work in image recognition are a combination of unsupervised and supervised machine learning algorithm. First supervised algorithm is used to train the model on the labeled datasets, i.e., examples of the depiction of the objects. Then the unsupervised algorithm is used to explore an input image. After this, a supervised algorithm kicks in and classifies the patterns as related to the particular category of object (for example, an ink pen).

THERE ARE TWO MAIN USE CASES FOR IMAGE RECOGNITION:

- **Visual Search** features are widely used in Search Engines and eCommerce marketplaces. It works the same way as alphanumeric search query only with images. In both cases, image recognition constitutes a part of the equation. The other part is image metadata and also additional textual input. This information is used to increase the efficiency of the results and to filter the selection of options according to the context. For example, such technologies are widely applied by Google Search and Amazon.
- **Face Detection** is widely used in social networks services, such as Facebook and Instagram. The same technology is used by law enforcement to find a person of interest or criminals on the run. The technical process behind face detection is more intricate than simple object recognition. To recognize the appearance of a certain person, the algorithm needs to have specialized labeled sample set. However, due to privacy limitations, these features are usually optional and require user consent. One of the better-known examples of this technology is VeriLook SDK.

ISSN:0971-1260

Vol-22-Issue-10-November-2019

AI ASSISTANTS, SPEECH-TO-TEXT, AUTOMATIC SUBTITLING - VOICE RECOGNITION

The sound is an equally important source of information as any other. With the rapid development of machine learning algorithms, it became possible to use it in providing basic services.In essence, voice recognition works on the same principles as OCR. The only difference is the source of information.

Voice and sound recognition are used for the following purposes:

- **AI Assistants / Personal Assistant apps** use natural language processing to compose the message and additional database of sound samples to perform the message. For example, Google Assistant;
- Sound-based Diagnosis - uses the comparative database of sounds to detect anomalies and suggest a possible cause and ways of fixing it. Commonly used in the automobile industry to inspect the state of the engine or the parts of the vehicle.
- **Speech-to-text and text-to-speech transformation** use comparative database of samples, OCR engine and speech generation engine. Outside of AI assistants, it is also used to narrate written text (for example, this feature is available on Medium);
- **Automatic Captions** addition involves speech-to-text recognition and subsequent image overlay to present the text on the screen (for example YouTube or Facebook automatic subtitling features).

ISSN:0971-1260

Vol-22-Issue-10-November-2019

AUDIENCE RESEARCH, CUSTOMER SERVICE, PRESCRIPTION, RECOMMENDATION - SENTIMENT ANALYSIS

Sentiment Analysis is a subset of pattern recognition that takes an extra step to define its nature and what it can mean. In other words, it tries to understand what is behind the words - the mood, opinion and, most importantly, an intent. It is one of the more sophisticated types of pattern recognition. Sentiment solutions can be used to explore the variety of reactions from the interactions with different kinds of platforms. To do that, the system uses unsupervised machine learning on top of basic recognition procedure. The assumptions of the sentiment analysis are usually grounded in credible sources such as dictionaries, but it can also include more customized databases depending on the context of the operation.

The use cases for sentiment analysis include:

- **Audience Research, content optimization, customer relationship platforms** - used for the further definition of the audience segments, their interaction with the content and analysis of the sentiments regarding it. Also contributes to the further optimization of the content. Such features are now tried out by Salesforce's Einstein Platform services.
- **Service Support** - provides an assistance in defining the nature of the query (whether it is positive or negative, combative or poorly defined). This feature is commonly used in AI assistants like Alexa, Siri, and Cortana;
- **Prescription / Recommendation** - used to predict the content of interest for the particular user. The suggestion may be augmented by the queries and past history of service use. The best examples are Netflix with their "you might also like" and Amazon with "people also buy";

CONCLUSION

Pattern recognition is the key to the further evolution of computational technology. With its help, big data analytics can progress further and we can all benefit from the machine learning algorithms getting smarter and smarter. As you can see, pattern recognition can be implemented in any kind of industry because where there is data, there are similarities in the data. Therefore, it's wise to consider the possibility of implementing this technology into your business operations to make them more efficient.

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ISSN:0971-1260

Vol-22-Issue-10-November-2019

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