Automated Detection of Counterfeit Consumer Goods using Product Inherent Features

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Abstract – It is a fact that counterfeiting jeopardizes the success of companies all over the world through violating intellectual property rights and causing enormous economic damage. Therefore it has become necessary for companies to secure their brands against counterfeiting. Existing technologies for automated counterfeit detection include the application of additional security features like Data Matrix Codes or RFIDs added to the brand product itself which raises the costs of the product. This text shows a new approach to secure a brand product by detecting product inherent features gained through the production process and the used materials.

1. Introduction

The annual "Report on EU customs enforcement of intellectual property rights" of the European Union in 2012 [1] shows a continious upward trend in the number of shipments suspected of violating intellectual property rights. As for the Year 2011 the value of detained articles and their equivalent genuine products is estimated to be over 1.2 billion euro. This number only includes the value of products actually detained only at the european border. The OECD report "The Economic Impact of counterfeiting and piracy" [2] of 2008 estimates a total loss of 250 billion dollars in the year 2007 worldwide[1]. The OECD report covers the analysis of international trade in counterfeit and pirated products. These estimates do not include domestically produced and consumed counterfeit and pirated digital products being distributed via the Internet. If these were also considered, the magnitude of counterfeiting and piracy worldwide could be several hundred billion dollars more than previously thought, and this increasing trend is quite alarming.
With the magnitude of counterfeiting and piracy in mind, these reports emphasize the need for more effective enforcement to combat the counterfeiting and piracy on the part of governments and businesses alike. A key component for this enforcement is the development of methods for automated counterfeit detection.

2. State-of-the-Art

Common automated counterfeit detection methods require nowadays additional security features at the product itself. Several methods have been developed, but main advantages and disadvantages remain similar.
Additional security features require further steps in production to add these features to the product. This raises expenses, manufacturing time and development efforts, which is clearly a disadvantage. On the other hand the security is enhanced and an original brand is easy to detect in an automated fashion, since there is a specific feature to look for. But this could also be a main disadvantage, if the security feature itself is easy to reproduce and could be added to any forged product.

2.1. Artificial Security Tags

The Anthology "Identification technologies to provide effective protection against product piracy" [3] gives a comprehensive overview of the latest efforts in product protection. A reasonably well studied approach is the extensive supervision of supply-chains. Here the application of RFID tags plays a significant role, as the latest form of artificial security tags, which can easily be integrated with existing logistic chains. The application of Data Matrix Codes (DMC) is discussed as well as a cost-effective alternative.

2.2. Usage of Product-Inherent Features

A novel approach to protect high-value products from counterfeiting is adopted in the project Inherent-ID [4], initiated by the Fraunhofer Cluster of Innovation 'Secure Identity Berlin-Brandenburg' and elaborated by the Department of Industrial Automation Technology at Technische Universität Berlin. The Project aimes to answer the question: Which inherent features allow separation of genuine products from counterfeits in an automated fashion? The motivation of this question is the assumption that genuine products must differ in its

[1] In 2007 [1] states 43.671 cases compared to 91.254 cases in 2011

properties from its counterfeit, since the product pirate tries to maximize its profit by using material of inferior quality and misusing a trademark of a genuine manufacturer to feint the customer. One result of the project is that only a combination of features can detect counterfeits at a decent rate for different products.

3. The New Counterfeit Detection Approach in Detail

Optical 2D and 3D characteristics as well as olfactory characteristics are combined with one another to serve as proof of product identity. They form the basis on which electronic certificates of authenticity can be issued without the need for complicated explicit security markings. The identity characteristics captured by this range of sensors serve both for product identification and product authentication. At the same time this also offers opportunities for improving documentation of product flows in the supply chain. Within the scope of Inherent ID is the successful establishment of a laboratory providing multi-modal measurement equipment comprising multigas sensor array for olfactory analysis, high resolution camera for texture analysis and stereo vision, as well as range cameras for 3D feature extraction. Further research is conducted with the aim for increasing robustness of the sole test methods especially under ambiguous environments, integration into portable devices, implementing sensor data fusion for increased detection ratio, effortless integration into supply chains and developing efficient data models for storage of various features depending on the regarded product.

3.1. Texture

The Image texture itself is defined as a function of the spatial variation of pixel intensities [5]. A textural signature capable of capturing inherent features, and in particular capable of coping with various changes in the environment would be highly suited to describing and recognising image textures. Furthermore, the mathematical description of image texture should incorporate, identify and define the textural features that intuitively allow humans to differentiate between different textures. Numerous methods have been designed, which in the past have commonly utilised statistical models, however most of them are sensitive to changes in viewpoint and illumination conditions. For the purposes of mobile counterfeit detection, it is clear that this would be an important characteristic for the signature to have, as these conditions can not be entirely controlled. Recently a description method based on fractal geometry known as the multifractal spectrum has grown in popularity and is now considered to be a useful tool in characterising image texture. One of the most significant advantages is that the multifractal spectrum is invariant to the bi-Lipschitz transform, which is a very general transform that includes perspective and texture surface deformations [6].

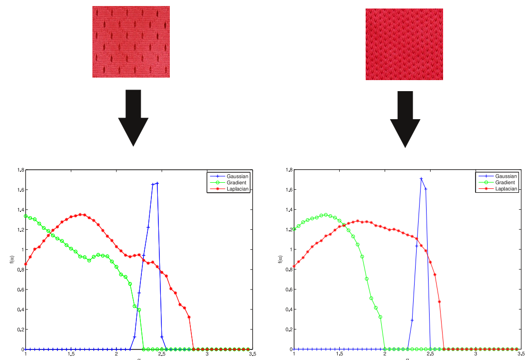

Figure 1: Multi-Fractal-Spectra of texture of a textile product (top) and its counterfeit

Another advantage of Multrifractal Spectra is that it has low dimension and is very efficient to compute in comparison to other methods which achieve invariancy to viewpoint and illumination changes such as those detailed in [7, 8]. One of the key advantages of multifractal spectra, which is utilised here is that they can be defined by many different categorisations or measures, which means that multiple spectra can be produced for the same image.
This is achieved through the use of filtering, whereby certain filters are applied to enhance certain aspects of the texture, to create a new measure. Certain measures are more or less invariant to certain transforms, and the combination of a number of spectra achieves a greater robustness to these. An example given in figure 1.

3.2. Visual Object Recognition using Shape

One distinguishable feature of brand products is the shape itself. Shape matching is a well studied topic and several publications can be found over the last 15 years. Feature-based approaches have become very popular since some years in image analysis (2D) due to robustness and less computational effort compared to other approaches. In shape matching (3D) feature-based approaches have been introduced more recently and are gaining popularity in shape retrieval applications for the same reasons. The major difference is whether the approach uses global or local features. In [9] an overview of shape matching principles and algorithms can be found.
Many shape matching approaches use digital human made data like the Princeton-Shape-Benchmark [10] or the SHREC datasets [11] to evaluate their algorithms. Scanned data from real world objects is different in a

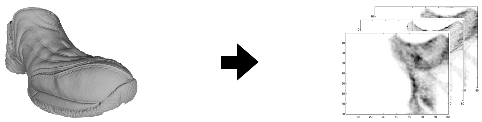

Figure 2: Transformation of Shape Features

sense that holes[2] and variations between two scans of the same object can appear.

For that reason most approaches are not suitable for counterfeit detection, where minor details of an object can be highly important. Therefore only approaches detecting local features were taken into consideration. The shape matching algorithm requires a three dimensional model of the product as input which can be matched to an abstract model of the brand product. The abstract model is a description of features that render the brand unique.

In our approach the concept of *Key-Points* or *Points-Of-Interest* in combination with transformation is used. To do so, a feature detector [11] has to be applied and the area surrounding the detected Key-Points is transformed into a meaningful descriptor.

Figure 2 shows a transformation of the area surrounding Key-Points into a 2D dense map using Spin Images [12]. A set of Spin Images is then transformed into a description of the object that can be matched to the abstract brand model.

3.3. Odour Sensing - Electronic Noses

Much effort has been spent on how odour could be measured. The European Standard EN-13725 [13] defines a method for the objective determination of the odour concentration of a gaseous sample using so called dynamic olfactometry. It is currently the only standardized method for the evaluation of odour impressions.

Every method claiming the ability to detect arbitrary odour emissions has to benchmark against this standard. An overview of the development and application of electronic noses is given in Gardner and Bartlett [14]. Beginning with the working principle of specific gas sensors the concept of electronic noses as a combination of sensor array and diverse pattern recognition algorithms for classification is introduced. A metal-oxide conductance sensor using 16 channels was utilized in the project Inherent-ID [4]. Here the sample gas flowing alongside the sensor surface is changing the concentration and configuration of oxide containing compounds, thus changing the conductance of the metal-oxide, which is then used as a measurement signal. The sensor elements differ by the thickness of silicon dioxide coating. Additionally the temperature is changed over time producing 16 analogue channels containing

[2]Holes are areas on the scanned object where the used scanning technique has troubles to capture data.

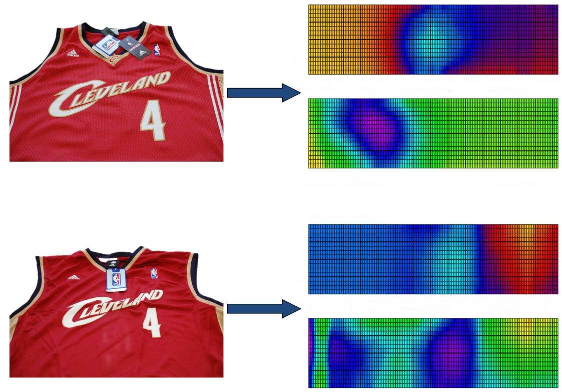

Figure 3: Olfactory pattern of a genuine jersey (top) and a counterfeit (bottom)

also transient responses, which are to be analyzed. Due to its working principle these sensors deliver the most unspecific data, which is both an advantage and a disadvantage at the same time, since the sensors are suitable for a broad variety of samples, but the signal processing is harder to implement.

Most of recently published results in odour detection are based on linear discriminant analysis and derivatives thereof cf. [15, 16] . These methods are efficient in classification of complex sensor data, but with a manageable number of classes. And these methods need a significant amount of data present and are therefore not suitable for the here elaborated problem of one to many matching, as needed for the application in counterfeit detection. An additional obstacle is the sensitivity to ambient conditions which result in wide variance of measurement data from the same class of samples. Effort is made in the extraction of relevant features for the purpose of reducing the dimensionality and the suppression of ambient influences which was done by independent component analysis. An attempt of designing a general odor model was made in [17], but was not successful due to the sensors used and the fact that non-linear behavior was excluded in advance. So the usage of specific models is more promising.

3.4. Workflow

With the features described above there is a strong basis for automated classification of patterns. An advantage of the proposed algorithms for feature extraction is the possibility to utilize statistical frameworks since the features are represented by probability distributions. In general there are various approaches possible. Starting with a direct fusion of the features as proposed in [18], or a more sophisticated approach which is taking the process of probing into account.

Here the decision process is not necissarily based on the utilization of all features, since some of them are dispensible or could be misleading. Think of the probing of shirt, obviously the 3D geometry cannot give a relevant contribution to the decision process and the 3D scanning can therefore be ommitted. The classification itself is done with an adjusted Bayesian approach where special account was given to the detection of novel and therefore unknown patterns. This was done with estimation of the Level of Signifcance distribution, which gives a decision information and an additional value of the plausibilty of this decision, cf. [19].

4. Conclusion

It was shown that the Inherent-ID Project adopts a novel approach to protecting high-value products from counterfeiting. The approach is based on the stationary and mobile capture of key product features indissolubly linked with the product which enable its production process to be traced. This not only renders the application of security tags obsolete but also gives enhanced protection against counterfeiting as the inherent characteristics that the high-quality production process impregnate in the genuine product are combined with one another to serve as proof of product identity.

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