

DATA ANALYTICS OF FOURIER-TRANSFORM
INFRARED SPECTROSCOPY (FTIR) FOR NON-HALAL
ADULTERATIONS

BY

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degree of Master in Information and Technology

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ABSTRACT

Advanced analytical practices such as data mining or predictive analytics are concepts that are increasingly vital in the area of large data sets. Voluminous data are collected over the years and it is important to assess the data quality for the value of information. Large amounts of data can contain knowledge in the form of patterns. What knowledge an organization especially the high-paced halal industry can get once data quality is assessed and data mining technique is applied? In this research, we have two objectives. Number one is to assess the data quality on the unstructured data collected from the Fourier-transform Infrared Spectroscopy (FTIR) instrument and number two is to identify patterns of halal and non-halal by applying decision tree technique for data mining. Cross-Industry Process for Data Mining (CRISP-DM) methodology is used in this research by adding data quality element on the preparation phase to stress out the importance of it before running a model for the dataset. RapidMiner is used to generate the prediction model by splitting the data collected into halal and non-halal substances and the result is visualized on its absorbance. Additionally, the performance vector analysis is also performed to make sure that the data is not over-fit. Among the result found in this study shows how big the difference of absorbance between the halal and the non-halal substance.

خلاصة البحث

تعد الاساليب التحليلية المتقدمة مثل استخراج البيانات والمعلومات أو التحليلات التنبؤية مفاهيم ذات أهمية متزايدة في مجال البيانات الضخمة. حيث يتم جمع كميات كبيرة من البيانات على مر السنين، ومن المهم تقييم جودة ونوعية هاته البيانات وذلك لقيمة المعلومات التي تحتويها. كما يمكن أن تحتوي هاته البيانات الضخمة على المعلومات في شكل أنماط. وهنا يكمن السؤال حول ما الذي يمكن أن تحصل عليها المنظمات وخاصة المنظمات المتخصصة في الصناعة الحلال عالية الوتيرة من هاته المعلومات بعد تقييم جودة بياناتها وتطبيق اساليب استخراجها؟ في هذا البحث قمنا بتحديد هدفين. اولهما هو تقييم جودة البيانات للبيانات الغير منظمة التي تم جمعها من جهاز التحليل الطيفي بالأشعة تحت الحمراء او ما يسمى بتحويل فورييه (FTIR). اما الهدف الثاني فهو تحديد أنماط العينات الحلال وغير الحلال التي تم تحليلها باستخدام أداة FTIR من مختبر المعهد الدولي للبحوث والتدريب الحلال. (INHART). كما تم في هذا البحث استخدام منهجية إدارة جودة البيانات (TDQM) من خلال استخدام طريقة الملاحظة الميدانية، والمقابلة مع أصحاب المصلحة، ومراجعة البيانات التي هي من الاهداف الاساسية للبحث. كما تم استخدام تقنية شجرة القرار (Decision tree) لاستخراج البيانات وتم ذلك عن طريق تصنيف مجموعة العينات استنادًا إلى صفة الحلال فيها.

APPROVAL PAGE

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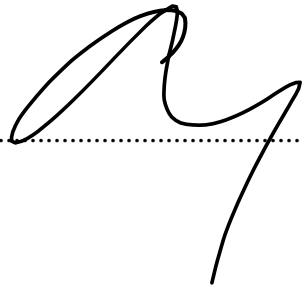
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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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Signature

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In the name of Allah, the Most Gracious and the Most Merciful, along with Salawat and Salam to our role model, Prophet Muhammad SAW.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In recent years, Information Technology (IT) has been rapidly growing and being used in multiple sectors such as education, finance, healthcare, as well as halal industry. The use of Information Technology (IT) will positively improve the day-to-day process of an organization as well as the end result for the product they are developing.

Similarly, the world society has started to understand the importance of muslim requirement for food and any other services known as halal (Elasrag, 2016). Halal is a Quranic phrase that means allowed, permitted, or lawful. Its opposite is haram (forbidden, unlawful or illegal).

It is essential for the world society, both Muslim and non-Muslim, to identify the potential of the halal industry because it is the emerging billion-dollar market. By tapping into this halal industry, it could further develop the economy just as it would assist to crack some of the long-standing problems faced by the Muslim community (Elasrag, 2016).

Despite all of these exciting trends, the halal industry faced a few challenges and one of them is food adulterations. Food adulteration is the act of purposely degrading the quality of food. The way it is done is by admixture or substitution of inferior substances or by the removal of some valuable ingredient. (Fadzilah et al., 2011). Adulterants might be purposely added to more substances to increase visible quantities, reducing manufacturing costs, and other misleading or malicious purposes.

Fourier Transform Infrared Spectroscopy , also known as FTIR Analysis or FTIR Spectroscopy, is an analytical technique used to identify organic, polymeric, and, in some cases, inorganic materials. The FTIR analysis method uses infrared light to scan test samples and observe chemical properties. FTIR is mainly used to identify and characterize unknown material for example solids, powders, or liquids. Sometimes it can also be used to identify contamination on the material as well as identify additives, oxidation, decomposition, or uncured monomers in failure analysis investigations. Furthermore, the use of FTIR can be observed in animal-based product such as bovine, porcine, fish, and many more. Many data are generated using FTIR and voluminous data can be seen processed daily in multiple labs or institutions.

When talking about voluminous data, the importance of data quality needs to be mentioned as well. Data quality is the procedure of training the data to meet specific needs of business user. Accuracy, completeness, consistency, timeliness, uniqueness, and validity are the principle measurement of data quality (Talend, 2020). Apart from that, an organization needs to pay attention into their data quality in order to understand its business and what are the key decision moving forward. The amount of data which exist in today's world is truly overwhelming. Poor data quality costs risen by 50% in 2017, reaching 15 million dollars per year for every company (Talend, 2020).

Poor data quality will remain to affect brand reputation if nothing is done. It will then undoubtedly become a company's responsibility to bring trusted and governed data. It translates to everybody is the company should be aware of their individual responsibility.

Identifying a pattern in the clean data can be a way to extract a meaningful insight towards the company's needs. Data mining is the procedure of discovering meaningful new

relationships, patterns and trends by examining through large amounts of data stored in storehouses, using pattern recognition technologies as well as statistical and mathematical techniques (Larose, 2005).

Data mining is becoming more extensive every day, because it inspires companies to discover profitable patterns and trends from their existing databases. Companies and institutions have spent millions of dollars to collect megabytes and terabytes of data but are not taking advantage of the valuable and actionable information hidden deep within their data repositories. However, as the practice of data mining becomes more widespread, companies that do not apply these techniques are in danger of falling behind and losing market share, because their competitors are using data mining and are thereby gaining a competitive edge (Larose, 2005).

One of the methodologies which being used massively in the organization for data mining technique is Cross-Industry Process For Data Mining (CRISP-DM). It provides a non-proprietary and easily available standard process to fit data mining into the general problem-solving approach of an industry or research unit.

As can be seen from the benefit of both data quality and data mining above, it is the aim of this study to identify the potential benefits that data mining can bring to the halal industry sector especially on the sample data generated by the FTIR instrument. The study will use a large sample set of FTIR result data, and a decision tree will be used as a data mining technique.

1.2 PROBLEM STATEMENT

The precondition in guaranteeing the best result possible in analyzing data is by having high-quality data (Cai & Zhu, 2015). The result of having poor data quality might turn them to become inaccurate, which may cause on wastage of resources, harming the organization internally, and with its customers (Lucas, 2010). Without solid data, an organization might not reach a good decision due to a lack of understanding of things that are happening within the organization itself (Eckerson, 2002). Eckerson (2002) also describes that several problems that might appear due to poor data quality can include loss in revenue, customer dissatisfaction, loss of credibility in a system, delay in deploying a new system and extra time in data reconciliation. Assessing the quality of data is compulsory to avoid making a wrong decision (Abarza et al., 2014).

Lucas (2010) stated that Data Quality Management (DQM) is a growing issue to the academic and professional communities. The starting point of furthering data quality is the Data Quality Assessment (DQA) according to Liu et al., (2017). It is crucial to assess data quality before any other related activities which involve using those data. Ruan et al., (2009) discovered that using regular expressions to analyze and verify the data can help the organization to improve the data quality. The implementation of this proves the practicality for data quality analysis. Placing a stakeholder in the loop in the quality assurance process is another concept for assuring data quality. In which most of the time, users contain the domain-specific knowledge of this application (El Bekri, N. 2016).

Furthermore, ensuring a high data quality level is another vital matter to increase the productivity of the business developments. Having poor data quality might turn these data into incorrect information - which can lead to negative effects for the growth of the

business. So, by recognizing data quality issues to begin with, this would create a positive effect on efficiency of the business processes (Panahy et al., 2014).

Food safety, food processing, and marketing sales in general are some of the series of challenges in data mining techniques in the food industry (Vlontzos & Pardalos., 2017). Today, the most vital methodologies which are currently being utilized are clustering, classification, feature selection and outlier detection. On top of that, ensuring the best quality of the final products is also an important issue in food processing networks. (Beulens et al., 2016).

One other concern in the food industry that exists today are the quality of the supply chain monitoring system. By having this well-defined data such as supplier name, restaurant location, ingredients just to name a few examples – any sort of problems can be prevented in the early stage. With the application of data analysis, this would be extremely beneficial not only for the food industry but also for food producers as well (Allouche, 2018).

Lack of monitoring and control from the government to the food producer in their part to meet halal necessity is one of the challenges that the halal industry's faced (Majid et al., 2015). Majid et al., (2015) also specified that back then, the attitude of the Muslims towards halal products was based solely on 'pork and alcohol-free'- whereby the concept of halal is supposed to come as wholesomeness of the food products. The importance of having these halal logistic partners and warehouses to implement this practices according to halal procedures is just as crucial as its logistic activities here in Malaysia – such as ensuring that there is no presence of any doubtful or haram substances on its products' ingredients or materials (Idha et al., 2018).

Similarly, food adulterations are rather an ancient world problem than a current world issue. In ancient Rome, foods, medicines, and cosmetics were often subject to adulterations in numerous usages. As foods and other natural goods were dealt through the large Roman Empire, they were level to decay during shipment and storage. Consequently, common techniques of adulteration were mixing of spoilt food with fresh food or the deceitful introduction of colouring or masking additives (Bush, 2002).

Several methods can be used to detect food adulterations, particularly on meat products. Among the techniques is based on DNA analysis. Because of the high constancy of DNA and universal application to all cells, DNA-based methods are ideal for detecting food adulterations. Polymerase chain reaction (PCR), DNA barcoding, nucleic acid biosensors, and chips have been proposed for species identification of meat (Kowalska, et al., 2019)

1.3 RESEARCH PURPOSE

The purpose of this study is to assess the quality of the data from the FTIR instrument used by the International Institute for Halal Research and Training (INHART) to detect halal and non-halal adulterations. As of today, the result of the FTIR instrument is still in raw data. By assessing the quality of the data, it might help to boost the efficiency of the business processes. As mentioned, poor data quality often leads to wrong information, which later on could steer to the failure of the business process improvement (Panahy, et al., 2014).

Additional purpose is to recognize originality of data and its significance on data improvement. Categorizing the relationship of data quality dimensions with the business

process enhancement benefits INHART as an important institution in providing education and services in halal industry. By tackling this issue on the first stage of data improvement, it will lessen the cost of the system improvement as well as remove the overlapping processes and activities (Panahy et al., 2014).

Furthermore, this research will boost confidence level for the researchers who are using FTIR and bring the satisfactions for each analysis that runs with an FTIR instrument.

1.4 RESEARCH OBJECTIVES

The objectives of this research are the following:

1. To assess the data mining technique on the unstructured data collected from INHART's FTIR dataset.
2. To identify patterns of halal and non-halal samples that have been analysed using the FTIR instrument.

1.5 RESEARCH QUESTIONS

The research questions of this research are the following:

1. How cross-industry process for data mining (CRISP-DM) can benefit INHART from making the decision?
2. What are the patterns for samples that have been analysed using an FTIR instrument?

1.6 OPERATIONAL DEFINITIONS

1.6.1 Data Quality Assessment

It refers to the process of evaluating the data using specific data quality metrics and dimensions according to company special needs. This assessment aims to provide valuable insight into the areas that need improvement (Pipino et al., 2002).

1.6.2 Data Quality Management

The term refers to a business principle that requires a combination of the right people, processes, and technologies - all with the common goal of improving the measures of data quality that matter most to an enterprise organization (Scruggs, 2018).

1.6.3 Pattern Recognition

It refers to the act of taking in raw data and taking an action based on the category of that data. It aims to classify data based on a priority or statistical information extracted from the patterns. Algorithms are then used to detect statistical regularities in the data to classify new data (Chapman, 2018).

1.6.4 Halal & Non-halal

Halal is a term solely used in Islam which means permitted or lawful. Non-halal or haram means forbidden where the products contain pork or its by-products, prohibited food ingredients of animal origin, alcohol, and the product that has not been prepared and manufactured on clean equipment (Majid et al., 2015)

1.6.5 Food Adulterations

It refers to a process of prohibited substances are either added partially or wholly substituted. Contamination or adulteration in food is added for various reasons which includes financial gain, carelessness and lack in proper hygienic condition of processing, storing, transportation and selling (Sharma et al., 2017)

1.7 ASSUMPTIONS

The following assumptions are made concerning this study:

1. By applying data quality assessment, INHART as an organization will be more informed in the decision-making related to the FTIR instrument.
2. By applying a data quality assessment, it will give an INHART a competitive advantage because of the valuable data resources FTIR instrument produces.

1.8 LIMITATIONS

This study, however, is limited to FTIR results for halal and non-halal adulterations under International Institute for Halal Research and Training (INHART) under IIUM, as it assesses exclusively on the data quality for non-halal adulterations using the FTIR instrument. By the end of this study, we will also attempt to extend the data analytics usage in halal's science, particularly in INHART.

The scope of the study will focus on data quality assessment for halal and non-halal adulteration generated by the FTIR instrument. Then, assess the raw data that the device produced to detect which elements drive a product to be considered as halal or not. This

study will also involve stakeholders from INHART to decide what key attributes to detect non-halal adulterations. As for the analytical tool, RapidMiner will be used for data quality assessment as well as data preparation and predictive analytics.

1.9 RESEARCH SIGNIFICANCES

The findings of this study would explore the true potential uses of experimental data in the domain of halal science and how this experimental research can benefit halal science sector, specifically on big data sets. It would also provide the fastest analysis in determining halal & non-halal adulterations done by INHART. Also, some information can be provided on how to optimize the data to produce the maximum result to the extent of data analytics. Such findings can be utilized to optimize the data that is produced by the FTIR instrument whereby, it would speed up the time to obtain the result for finding non-halal adulterations. On top of that, researchers of INHART's lab can take advantage of this study to magnify the accuracy of the data that the machine generates.

Based on this data mining technique, the collected data from FTIR may play an essential role in seeking patterns, mining associations, correlations, and other relationships within the data. It would also help in classifications of data, clustering, as well as other data mining tasks (Han et al., 2012). This would help INHART's team to explore what can be optimized from the current data sets.

CHAPTER TWO

LITERATURE REVIEW

2.1 HALAL INDUSTRY

One of the most important concepts in Islam is the concept of Halal, which Halal industry plays a massive significant role in the world, especially to the Muslim society (Abd Aziz et al., 2015). With the continuous increase of global Muslim population, it creates a higher demand for halal food, products, and services (Sulaiman, 2016). As we talk about halal food, the topic of halal market must be taken into the top list of discussion, whereby its logistics and supply chain industry are considered as very dynamic. Consumers demand high quality halal products across the world, and it must have a high attention (Sarah et al., 2011).

As the Islamic economy continues to grow, it was estimated that Muslim spend US\$1.3 trillion in 2017 alone for the consumption of food and beverages. It was also recorded that Muslims worldwide spend US\$87 billion and US\$62 billion for pharmaceuticals and cosmetics respectively (Reuters & Standard, 2018).

Feizollah et al. (2019) experimented on data extraction and sentiment analysis by using a stack of deep learning algorithms for halal products on Twitter and the results show that the public's response towards halal tourism and halal cosmetics are positive – with the sentiment score of halal cosmetics is higher compared with halal tourism. This indicates that halal cosmetics have a big prospect in the business opportunity and could have to return massive profits in the future.

Omar & Jaafar (2011) stated the market of halal products is broadly distributed across the world. This leads to an increase to the demand for halal products – which are not limited to Muslim countries but also non-Muslim countries. Consequently, this triggers the products to become well-known globally as it highlights the needs for a halal supply chain. Due to this reason, halal supply chain plays a vital part as they underline the concept of halal is not only applicable to the food, but also including the entire supply chain starting from farm sourcing until it reaches to the hands of customers.

Subsequently, several factors have been identified that led to an applicable halal supply chain about the food consumption in Malaysia. Each segment in the halal supply chain is essential on classifying the critical halal control point which can make the halal product turn out to be non-halal products because of the contamination with the non-halal product on any point of time during storing, packaging, handling and transporting the products (Omar & Jaafar 2011).

In Malaysia, ‘Halal Square’ mobile application is created for users to access the information about halal products. This application is developed by Halal Industry Development Corporation (HDC) together with JAKIM. However, the study that has been done by (Abu Bakar et al.,) demonstrates that consumers do not put high trust towards the apps themselves. But, consumers agreed that such a platform is still informative as it helps to raise more awareness among consumers about halal products.

Another area of halal science is in pharmaceuticals, which holds the equivalent importance to get it halal authenticated for its food and pharmaceutical products as the concern on the prohibited non-halal substances could always be present (Hassan et al., 2018).

As one example, a method for rapid detection of ethanol (EtOH) substance in beverages using portable electronic nose (E-Nose) has been successfully conducted and currently in-use in this industry. This device has been extensively used in food analysis, in which one main feature is to mimic the human in-body system. Based on the previous studies, this kind of portable device to detect halal composites is extremely needed in the market.

The portable E-Nose, which in fact developed by International Islamic University Malaysia (IIUM), turns out to be very reliable for the detection of EtOH in various beverages such as alcoholic beverages, isotonic drinks, soft drinks and fruit juices of different brands in Malaysia. With its high accuracy and reliability, this powerful device could detect EtOH content as low as 0.1%.

The significance of having this kind of device is to detect availability of EtOH presence in beverages sold in Malaysia which is proven to be reliable to be utilized. E-Nose could authenticate the alcoholic drinks and display the concentration in a range and can verify the contamination of EtOH in the drinks that has a halal logo from the producer (Ab Mutalib et al., 2013).

2.2 CHALLENGES IN HALAL INDUSTRY

According to Tieman, improper hygienic practice in premises as well as the expiration of halal certification is currently one of the halal issues that Malaysia has been facing (Tieman, 2007). This occurs due to the strictness in the concept of halal on food which extends to not solely on “pork and alcohol” free, but it must be the wholesomeness of it, without any exception. For example, its gelatine, enzymes, colourings, breadcrumbs should not be