

# Seminar on Current Topics in Business, Information Technology and Analytics (BITA'14) October 13, 2014

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## Abstract

The working papers included in this series were presented at a research seminar at Arcada University of Applied Sciences titled “Seminar on Current Topics in Business, Information Technology and Analytics” (BITA'14) and their purpose is to give a broad overview of current research at Arcada. Karlsson, Westerlund, Pulkkis and Dooley focus on identifying relevant features characterizing various types of wormhole attacks in mobile ad hoc networks (MANET), which are needed for generating training data aimed at wormhole attack detection utilizing machine learning based algorithms. Eriksson and To discusses segmentation for baby boomers in the mobile services market in Finland. Mildén and Boguslawski are providing a survey of a study where two quantitative methods were combined for solving an empirical design problem in an experimental setting: How to measure the importance of non-salient image elements. Eldon presents a study of the process of application for a study place at a university and analyses who and what influence the students' selection process. Finally, Grahn provides a brief introduction to the current state of electronic nose technologies which have a clear potential to be a non-invasive, simple, rapid, and accurate human odor detection and classification tool.

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# Feature Engineering for Detection of Wormhole Attacking in Mobile Ad Hoc Networks with Machine Learning Methods

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## Abstract

Due to the self-configuring nature of a Mobile Ad Hoc Network (MANET), each node must participate in the routing process, in addition to its other activities. Therefore, routing in a MANET is especially vulnerable to malicious node activity leading to potentially severe disruption in network communications. The wormhole attack is a particularly severe MANET routing threat since it is easy to launch, can be launched in several modes, difficult to detect, and can cause significant communication disruption. In this paper we establish a practice for feature engineering of network data for wormhole attack prevention and detection with intrusion detection methods based on machine learning.

**Keywords:** Mobile Ad Hoc Networks, MANET, wormhole attack, feature engineering

## 1 INTRODUCTION

A Mobile Ad Hoc Network (MANET) is a self-configuring arrangement of mobile devices interconnected by wireless links, with no fixed infrastructure like base stations and dedicated routers. MANETs can be used e.g. for establishing wireless sensor networks, vehicular networks, military communications, extreme rescue operations and providing Internet connectivity where some nodes are located out of radio range of an Internet connection point.

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Due to the self-configuring nature, each MANET node participates in the routing process, in addition to its other activities. Several routing protocols have been proposed for MANETs, such as Ad Hoc On Demand Distance Vector (AODV) (Perkins & Royer 1999) and Dynamic Source Routing (DSR) (Johnson & Maltz 1996), but security has typically not been a priority in routing protocol development (Taneja & Kush 2010). Consider for example a large scale MANET that is integrated in the future world of Internet of Things (IoT), where devices both dynamically and autonomously enter and leave the network, and it is therefore difficult to establish trust relationships among the nodes. Consequently, routing in a MANET is especially vulnerable to malicious node activity leading to potentially severe disruption in network communications (Karlsson, Dooley & Pulkkis 2012, Agrawal, Jain & Sharma 2011). Such disruption can range from deliberately ignoring the routing protocol to tampering routing packets. For example, to save energy a selfish node may simply not take part in the routing process leading to packet loss, while a malicious node can launch serious network attacks, such as rerouting packets from their original path to an erroneous destination node and even stealing the identity of a node.

The wormhole attack (Hu, Perrig & Johnson 2003) is a particularly severe MANET routing threat since it is easy to launch, can be launched in several modes, difficult to detect and can cause significant communication disruption. Two collaborating malicious nodes create a fictive shortcut link in the network by forwarding routing packets to each other with the intention to attract more data packets to traverse the wormhole link. Once the wormhole has been successfully established, the malicious nodes can disrupt network operation by either dropping packets or launching more serious attacks, such as eavesdropping and packet sniffing.

A wormhole attack can be launched in either hidden mode (HM) or participation mode (PM) (Khabbazian, Mercier & Bhargava 2006). In a HM wormhole, malicious nodes capture and forward routing packets to each other without modifying the actual packets, so the wormhole nodes never appear in routing tables. A PM wormhole operates in the same way as a HM wormhole with the exception that the malicious nodes process routing packets as any pair of legitimate nodes and thus appear in a wormhole infected route as two contiguous nodes. The malicious nodes can forward routing packets to each other using either an in-band (I-B) or out-of-band (O-B) wormhole link. I-B tunnels packets between the malicious nodes via genuine network nodes. O-B wormhole links are more complex from the attacker's point of view because they require an external communication channel, i.e., network cable or directional antenna, to establish a direct link between the wormhole nodes.

Due to the open nature and lack of dedicated central nodes such as routers, routing security in MANETs cannot rely on cryptography. Instead, security must be based on anomaly detection and trust in the network established based on node behavior. Several proposals for Intrusion Detection Systems (IDSs) for MANETs have been proposed in the literature but they typically do not take all types of attacks into account, especially not all wormhole attack types. Many research papers also propose mechanisms for detecting specific threats, but in a realistic MANET the most convenient solution would be a comprehensive IDS capable of identifying at least all severe routing attacks.

In feature engineering the most important factor has been considered to be the features used. For many independent features correlating well with a class, learning has been easy. However, if a class is a very complex function of the features, then it might be impossible to learn such a class. When the raw data is not in a form that is amenable to learning, features can still be constructed from it. It has been considered that most of the effort in a machine learning project goes to feature engineering. (Domingos 2012)

In this paper we look at the feature engineering task of identifying wormhole attacks by pre-formatting MANET data for an IDS based on Machine Learning data. The contribution of this paper is to identify specific features of each wormhole attack type for distinguishing the difference between healthy and wormhole infected routes. These features can then be utilized for creating training data.

The rest of the paper is organized as follows. In Chapter 2 an overview of previous feature engineering related research on IDS for MANETs is given. Chapter 3 provides a detailed overview of the different wormhole attack types and points out the specific features differentiating wormhole infected routes from healthy routes. Finally, some concluding comments and plans for future research on machine learning based IDSs for MANETs are presented in Chapter 4.

## 2 RELATED RESEARCH

The fundamental goal for machine learning based IDSs is to generalize beyond the examples in the training set. Hence, capturing the underlying complexity of the raw data set when performing feature engineering is of outmost importance. Simply reducing data dimensions or compressing data is often difficult, even for a well-known problem. Intrusion attack metrics are needed in feature engineering for machine learning based IDS implementations. Four wormhole attack metrics are defined in (Mahajan et al. 2008):

1. *Strength*: the number of end-to-end routing paths passing through a wormhole tunnel.
2. *Path Length*: the length difference between an advertised routing and an actual routing path.
3. *Attraction*: the decrease in routing path length offered by a wormhole.
4. *Robustness*: the persistency of a wormhole without a significant strength decrease for minor network topology changes.  
Maulik & Chaki (2010) add a fifth wormhole attack metrics to this list:
5. *Packet Delivery Ratio*: number of delivered packets divided by the total number of dispatched packets.

Use of information entropy in feature engineering for selection of most relevant features in an IDS based on machine learning is shown in (Kayacik, Zincir-Heywood, & Heywood 2005, Tang, Jiang, and Zhao 2010). A methodology to calculate the Information Gain (IG) (Information 2014) for each feature and for each intrusion attack class in a training dataset for machine learning is presented and applied to the “10% of KDD CUP 1999” dataset (KDD 1999). The most relevant feature in each class (22 intrusion attack classes and the normal class) is defined by the highest IG in comparison with other features. Features in a subset of size 10 from a set of 41 features in the training dataset had

the highest IG in at least one of the 23 classes and these ten features were chosen for the testing phase. A SVM-based machine learning algorithm TASVM (Triangle Area Based SVM) was proposed and used in the testing phase in (Tang, Jiang, and Zhao 2010). In comparison with two other intrusion detection models, intrusion detection rate was higher in binary intrusion detection (99.88%) and in four of five attack classes (at least 92,35 %) while false positive rate was about the same (2,99%).

Mahajan et al. (2008) proposed an IDS for detecting I-B wormholes created by three malicious nodes, a pair of wormhole endpoint nodes and a node for forwarding wormhole traffic. The link between the wormhole endpoint nodes is called a self-contained I-B wormhole, which can be extended to wormhole links between legitimate node pairs. The proposed IDS is based on anomaly detection in features representing measured delays:

- The difference between end-to-end delay and the sum of hop delays is anomalously large for wormhole infected routes.
- Hop delays in uninfected routes are anomalously prolonged in nodes used by a wormhole tunnel because of the tunneled network packets.

A hop delay is defined by the time spent in the sending node. Wormhole detection rate was in most cases 70 – 100 % in MANET simulation experiments with 4 randomly chosen topologies for 15 nodes in an area size of 1500\*1500 meter.

In (Barani & Gerami 2013) machine learning based on One-class Support Vector Machine (OCSVM) (Schölkopf et al. 2001) is used for anomaly detection of flooding, blackhole, neighbour, rushing, and wormhole attacks in a dynamic MANET. Each network node monitors own network traffic and measures own network state in a time slot as a p-dimensional feature vector. Each measured feature value is scaled to a [0,1] interval value for input to the used machine learning algorithms. Machine learning consists of an initial training phase and an updating phase integrated in the detection phase. Each node updates in each time slot the OCSVM feature vector set with detected normal feature vector and removes feature vectors with weights less than a given threshold. The dynamic MANET characteristics are taken in consideration by weights decreasing over time for feature vectors in the OCSVM feature vector set. In simulation experiments with 30 mobile MANET nodes a feature vector with 22 values was measured by each node at each time slot. Three features were related to the used constant bit rate traffic, ten features were related to the route discovery process, five features were related to route disruption, and four features were related to the used modified AODV routing protocol. In the detection phase one node was selected to be a malicious node, which launched flooding, blackhole, neighbour, rushing, and wormhole attacks. Inclusion of the updating phase improved average detection rate from about 50% to about 95% and decreased the average false positive rate from about 10% to about 2%.

In (Pastrana et al. 2012) the efficiency of intrusion detection in MANETs is evaluated for six classification algorithms i.e., Multilayer Perceptron, the Linear classifier, the Gaussian Mixture Model (GMM), the Naïve Bayes classifier, the Support Vector Machine (SVM) model, and Genetic Programming (GP) algorithms. Detection out four different attack types i.e. Black Hole, Forging, Packet Dropping, and Flooding was studied in simulation experiments with 50 randomly placed MANET nodes. Eleven input data features were used for anomalous network activity detection i.e., number of Route Request packets sent/received, number of Route Reply packets sent/received, number of

route error packets sent/received, number of bytes sent/received, number of one-hop neighbours of each node, percentage of changed routed entries in the routing table of each node, and percentage of the changes in the sum of hops in all routing entries for each node. For simulation experiments with a multiclass dataset intrusion detection rate was about 75%, false positive rate between 5% and 25% and class error about 20% for all six classifiers. Excluding GP, classification results were best for the machine learning based SVM model.

### **3 WORMHOLE ATTACK TYPES AND THEIR SPECIFIC FEATURES**

In this chapter, different wormhole attack types are described in detail and their individual features are highlighted. The knowledge of these features can be utilized for generating training data for Extreme Learning Machine (ELM), SVM, and other machine learning based IDS algorithms.

#### **3.1 Hidden Mode Wormhole**

Consider the MANET scenario shown in Figure 1 where S is the source and D is the destination. The shortest path in terms of hops from S to D is in this case S - I<sub>1</sub> - I<sub>2</sub> - I<sub>3</sub> - I<sub>4</sub> - I<sub>5</sub> - I<sub>6</sub> - D. However, if malicious nodes M<sub>1</sub> and M<sub>2</sub> launch a HM wormhole, the shortest path is S - I<sub>1</sub> - I<sub>6</sub> - D as I<sub>1</sub> and I<sub>6</sub> falsely appear to each other as neighbors since M<sub>1</sub> does not add its own IP address to the source field of the IP packet carrying the route request (RREQ) packet received from I<sub>1</sub> to be forwarded to its neighbors. Instead M<sub>1</sub> encapsulates the original RREQ packet into a new IP packet that is tunneled to M<sub>2</sub>. When receiving the tunneled RREQ, M<sub>2</sub> extracts the original RREQ packet and forwards it to its neighbors without modifying any of the routing packet parameters. Hence, to I<sub>6</sub> it appears the RREQ was sent from I<sub>1</sub> and as a result the IP address of I<sub>1</sub> is added to the routing table as next hop on the route towards node S.

A deviant feature of a route infected by a HM wormhole is that the distance between false neighbor nodes is significantly longer than between legitimate neighbor nodes. It is impractical to assume each node is able to get location information through a navigation system, such as GPS, but the distance can also be estimated for example by measuring the packet traversal time (PTT) of a packet between two nodes, as proposed in (Khabbazian, Mercier & Bhargava, 2006). Each node can thus keep track of the PTT between itself and its neighbors. This track keeping can then be used for analyzing the validity of a neighbor.

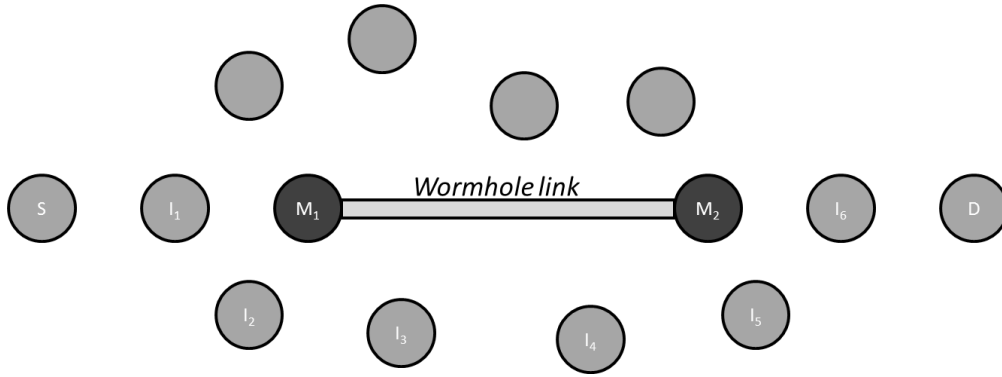


Figure 1. A MANET example scenario.

### 3.2 Participation Mode Wormhole

If  $M_1$  and  $M_2$  (see Figure 1) launch a PM wormhole, then the shortest path would be  $S - I_1 - M_1 - M_2 - I_6 - D$ . In this case, the PTT between  $M_1$  and  $M_2$  would be significantly higher than the PTT for any other pair of nodes. Since  $M_1$  can falsely confirm  $M_2$  as its neighbor and vice versa, neighbor validation is not reliable for identifying PM wormholes. However, PTT is still a reliable metric, if it is analyzed for a whole route, as is proposed in (Karlsson, Dooley & Pulkkis, 2011). So, a reliable and deviant feature of route infected by a PM wormhole is that PTT per hop count (HC) is significantly higher than for a legitimate route.

Assuming that the malicious wormhole nodes always use the same identities (such as IP and/or MAC address) and that a network node is able to collect and track information about each intermediate node on every found route, as in the dynamic source routing (DSR) routing protocol, a deviant feature is that the malicious nodes appear as legitimate neighbors on significantly more tracked routes than any other legitimate pair of nodes. The average HC of routes traversing the wormhole nodes may also be significantly lower than the HC of other routes not traversing the wormhole link.

### 3.3 In-band Wormhole Link

An I-B tunnel is shown in Figure 2. In this case when  $M_1$  receives a RREQ packet from  $I_1$  it encapsulates it into a new packet that is sent to  $M_2$  through legitimate nodes ( $I_3 - I_4 - I_5$ ). If a wormhole uses an In-band wormhole link it will produce a very high PTT since it includes packet processing delays at the nodes through which packets are tunneled. Thus PTT is a highly reliable metric for identifying such a wormhole.

### 3.4 Out-of-band link

An example of an O-B wormhole link is shown in Figure 3. On the other hand, an O-B link is much more effective than I-B as it has a significantly lower delay (meaning it will attract more traffic) and at the same time more difficult to detect based on PTT



analysis as it sets a high requirement upon the accuracy of the PTT measurement, especially if the wormhole is launched in PM.

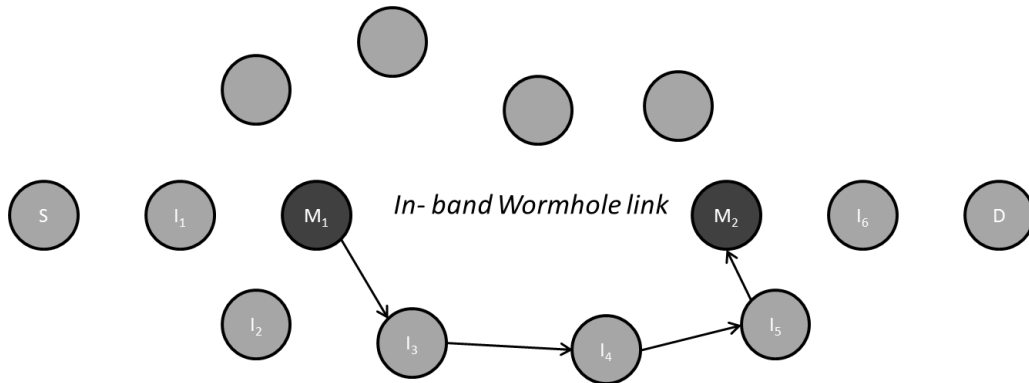


Figure 2. An example of an in-band wormhole link.

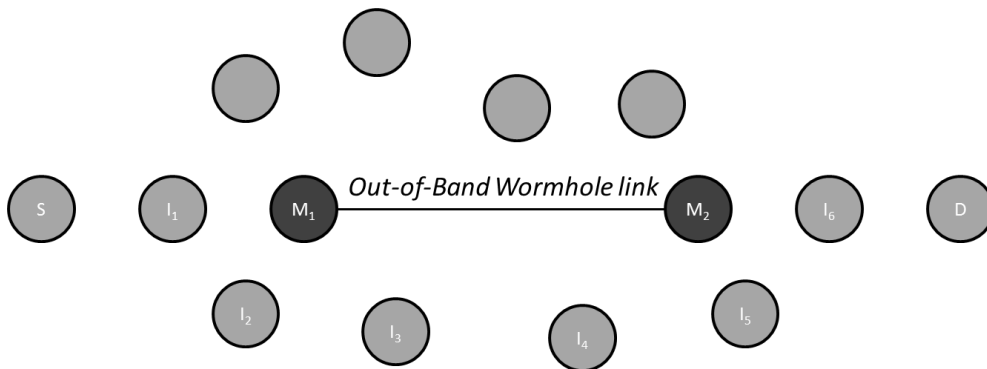


Figure 3. An example of an out-of-band wormhole link.

### 3.5 Summary of Features

The features that can be utilized and analyzed for identifying the specific wormhole types are summarized in Table 1. The only feature that can identify all four types of wormholes is PTT/HC. However, if the wormhole link has a low delay, i.e. launched in PM O-B, there is a high requirement upon the PTT measurement accuracy, since the difference between a healthy and an infected route is typically less than a microsecond. Therefore the wormhole attack detection precision can be strengthened by analyzing multiple features.

## 4 CONCLUSIONS AND FUTURE WORK

Machine learning based algorithms are effective for IDSs due to their generalizability. However, current algorithms proposed for MANETs are not capable of detecting all variants of the wormhole attack which is a severe threat on MANET routing. In this paper, specific features for each wormhole attack type have been identified. In terms of future research, the aim is to create training data based on the identified features needed

for making machine learning based algorithms capable of detecting all types of wormhole attacks. A long-term goal is to develop for MANETs a single adaptive IDS, which is based on machine learning and capable of effectively detecting/preventing all severe routing attacks, in order to eliminate the need for using multiple standalone security mechanisms.

Table 1. Features characterizing different types of wormholes and their estimated reliabilities: 1 = low reliability, 2 = medium reliability, 3 = high reliability.

WORMHOLE TYPE	O-B	I-B
PM	<ul style="list-style-type: none"> <li>- High PTT/HC (2)</li> <li>- Frequent appearance of specific node pair in routes (2)</li> <li>- Routes including specific route pair has lower average hop count (1)</li> </ul>	<ul style="list-style-type: none"> <li>- High PTT/HC (3)</li> <li>- Frequent appearance of specific node pair in routes (2)</li> <li>- Routes including specific route pair has lower average hop count (1)</li> </ul>
HM	<ul style="list-style-type: none"> <li>- High one hop PTT (3)</li> <li>- High PTT/HC (3)</li> </ul>	<ul style="list-style-type: none"> <li>- High one hop PTT (3)</li> <li>- High PTT/HC (3)</li> </ul>

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# Segmenting the Mobile Services Market for the Baby Boom Generation

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## Abstract

This paper discusses market segmentation for baby boomers in the mobile services market in Finland. Based on a literature review, we suggest a preliminary list of variables as base for the segmentation. The primary data will be collected using an online questionnaire as a research instrument. The results are expected by applying Self-organizing map (SOM) and K-means cluster analysis as a framework for the segmentation method.

**Keywords:** market segmentation, the baby boom generation, K-means, SOM, mobile services

## 1 INTRODUCTION

The penetration rate of mobile devices has been increasing dramatically. According to Ericsson (2013), smartphone subscribers will reach 5,6 billion in 2019. Along with the surge of smartphone devices, mobile Internet is also growing as a complement to fixed broadband subscription. In addition, mobile services have become a popular phenomenon recently. Among the mobile services, mobile apps have been consumed at a faster pace (Schoger, 2013). As a result of this, the revenues for mobile apps have been boosted.

Fig.1 shows the percentage of the increase in revenues of mobile apps between countries in 2013. As can be seen from the chart, the revenues inflated rapidly in two or even three digits. Especially for South Korea the revenues from mobile apps grew 759%, compared to the previous year. Actually, the growth rates are still high even in the well-established mobile markets, such as Japan (245%), Germany (90%), France (89%) and UK (64%).

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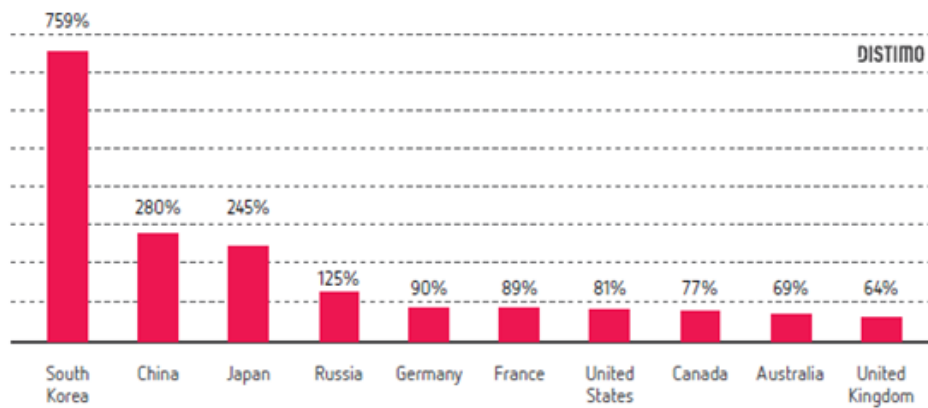


Figure 1- The growth of mobile apps' revenues in 2013 (Schoger, 2013)

In Finland where this study is conducted, 50% of the Finnish people use their smartphone 15 minutes after being awake in order to check SMS, e-mail and social activities (e.g. Facebook) (Deloitte, 2014). According to the same survey, 61% of Finnish mobile users have unlimited data connection (i.e. mobile internet). Furthermore, in a survey by Sell et al. (2014) SMS, e-mail, calendar functions, information searching (e.g. Google) and navigation (e.g. GPS) are the primary mobile services used by Finns on a smartphone. Moreover, subscription apps which require people to pay monthly/yearly fees for media consumption (Bresnahan et al., 2013) are a growing trend. It can be seen that mobile technologies and services are nowadays widely used globally and in Finland.

Recently there has been a gradual change in the population pyramid in Europe. In particular, there is an increasing rate of people who are from 50 to 79 years old in the community. This age group has been growing gradually from 2002 to 2013 (see Fig.2) and has a tendency to increase more. Thus, this consumer category should be paid attention to because it is an emerging potential market in the near future. By the end of 2013, the senior citizens account for 34,8% and 32,8% in Finland and EU respectively.

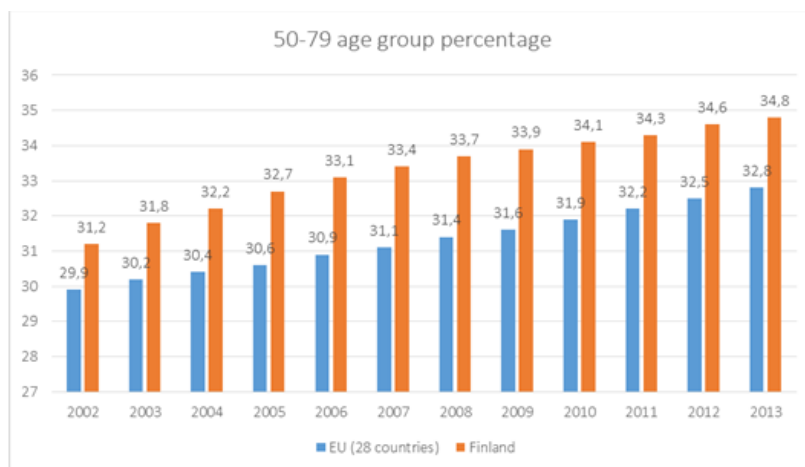


Figure 2- The proportion of 50-79 age group in the population in EU and Finland (Eurostat, 2014)

Among the aging population, there is a group that is a so-called baby boom generation. Born in the period of 1946 – 1964, this generation is the most discussed and studied by many researchers (Grable, 2013). Moreover, Rogers (2010) claimed that the group will be an evolving market by 2015.

## 1.1 Motivation for the study

The market for baby boomers is the new market of the 21st century (Chiger, 1998). This market is characterized by the differences in product consumption and adoption of technology. Consequently, Bigné et al. (2010) recommended not serving this group as homogeneous. Instead, we should focus on particular groups in order to achieve the expected benefit from marketing activities.

Sell et al. (2014) stated that there is a lower penetration of value adding features (i.e. mobile services), despite the high adoption of mobile technologies. In other words, even if there is a high adoption rate of smartphones, it does not guarantee a high adoption rate of mobile services. This statement illustrates that the mobile services do not necessarily meet the needs of potential customers. For example, the result from a survey in 2014 by Deloitte (2014) shows that 40% of Finnish users did not, during a period of one month, download any new mobile apps. In the one-year-earlier survey, the figure was 28%. It seems that people's intention to use new mobile apps is decreasing in Finland.

Therefore, with the emerging market and the ambiguity in mobile services, it seems highly beneficial and timely to conduct market segmentation in order to address the needs correctly.

## 1.2 The research objectives

The general research objective of this paper is to present our work-in-progress on market segmentation for baby boomers in Finland, based on their characteristics, use behaviors and attitudes toward mobile services. According to Wedel and Kamakura (2000) customers should be segmented according to *general base* (here baby boomer characteristics); *product-specific base* (here mobile service usage); and *unobserved product-specific base* (here attitudes towards mobile services).

There are three particular research objectives that need to be fulfilled in order to meet the general one:

- Provide a preliminary literature background for identifying the related variables (chapter 2)
- Discuss the methodology for conducting segmentation (chapter 3)
- Propose some expected results and preliminary plans for future research (chapter 4)

## 2 LITERATURE REVIEW

In order to partly address the research objectives, some previous approaches related to the baby boomers' preferences and the use of technology will be discussed.

### 2.1 Characteristics of baby boomers

This sub-section emphasizes the characteristics of baby boomers which should be relevant to mobile services in the Finnish context.

According to Statistics Finland (2013), the Internet is highly widespread in Finland and people use it for facilitating everyday matters such as email, online banking, online purchasing, online TV, and social networks. There is also a high penetration rate in use of the Internet among senior citizens, e.g. people who used the Internet in the past 3 months account for 85% in the 55-64 age group and 65% in the 65-74 age group. Regarding the possession of smartphones, the percentages for the 55-64 and 65-74 age groups are 45% and 25% respectively. Therefore, it can be assumed that at least a quarter of the senior citizens has smartphones and uses the Internet. Based on the described statistics we should distinguish between *age*, *type of mobile phone (basic vs. smart)*, *degree of Internet experience* and *degree of mobile Internet experience* when investigating Finnish baby boomers. Furthermore, characteristics such as *gender*, *number of children*, *financial capability*, *work status*, *education* and *marital status* are important to investigate when segmenting consumer markets (Oates et al., 1996). Therefore, these variables should also be included in the research.

Grable (2013) stated that personal wellness is a goal which the baby boom generation tries to achieve. For example, personal wellness involves social needs, physical and mental well-being. Therefore, it is beneficial if mobile services can meet the needs of baby boomers for personal wellness.

It is important to mention the retirement phase of baby boomers, because there is a significant change in their daily routines (i.e. what will they do if they do not go to work?). In order to facilitate this liminal state, there are some issues that need to be considered for retirement. Gilbaldi (2013) proposed that a typical boomer feels nine years younger than his or her actual numerical age. Therefore, considering baby boomers' cognitive age (i.e. feeling oneself at a younger age) should be more practical than focusing only on the numerical ages. Regarding the reasons for continuing working, some people want to work to earn money while others work to feel useful and productive. In addition, there are people who want to retire early because of illness (Migliaccio, 2013). These characteristics reflect the demands of personal wellness, and thus appropriate mobile services ought to be developed for these needs.

Consequently, in order to understand the differences in needs for mobile services, it seems highly important to research the *cognitive age (feel age)* of baby boomers, the *reasons for baby boomers to retire* and the *reasons for baby boomers to continue working*.

## 2.2 Possible determinants for baby boomers' use of mobile services

In this sub-chapter, we pick up and motivate factors which may influence the use of a particular technology, in this case, mobile services. The determinants are primarily based on the Unified Theory of Acceptance and Use of Technology for consumer context (UTAUT2) by Venkatesh et al. (2012).

Venkatesh et al. (2012) defined *performance expectancy* as the extent to which using technology will provide benefits to consumers. *Effort expectancy* is the degree of ease when consumers use technology. *Social influence* is the degree to which a consumer perceived that the important ones (e.g. friends and families) believe that he/she should use a technology. *Facilitating condition* relates to consumer perception of resource and support which are available to perform the behavior. In addition, *hedonic motivation*, i.e. enjoyment when using technologies is considered an important factor. Moreover, *cost* impacts significantly on the use of technology in the consumer context, because the consumers have to bear the cost of using technology. Furthermore, *habit* is also a critical predictor of technology use, as people tend to perform their work automatically based on previous learning (Limayem, Hirt, & Cheung, 2007).

There are, however, some limitations in validity for the findings of Venkatesh et al. (2012). In particular, Venkatesh et al. (2012) tried to identify which factors drive the use of one particular technology, i.e. mobile Internet. Therefore, the results may not be generalized to other technologies such as mobile services. Furthermore, because the mean of age in the study was skewed to 31 years old, the determinants are not necessarily meaningful for people who are significantly older (e.g. the baby boom generation). Consequently, the findings are most likely not correct with people who are significantly older (e.g. the baby boom generation) and thus there is a motivation to test if the variables in UTAUT2 play a significant role in segmenting the heterogeneous baby boomer market for mobile services. Furthermore, we need to extend the literature review to include a discussion on baby boomers' attitudes towards technology and individuals' attitudes towards mobile services. We have, therefore, in this paper added one variable to UTAUT2, namely technology anxiety.

Niemelä-Nyrhinen (2007) mentioned *technology anxiety* as an important factor influencing technology use. The higher the technology anxiety is, the lower the positive outcomes of overall satisfaction and usage frequency are of a technology. It should be noted that the same authors concluded that baby boomers in Finland have, generally speaking, a low level of technology anxiety. Studies in other contexts have, however, stated that baby boomers need an additional encouragement with technology, whereas the younger generations enjoy living with it (Seipert and Barhust, 2014). Also Nicholas (2011) implies that the baby boom generation is less comfortable with technology. As a result of this, baby boomers prefer a traditional face-to-face communication (Cennamo & Gardner, 2008).

Therefore, measuring technology anxiety towards mobile services for baby boomers should yield useful information. We can identify boomers who have different technology anxiety levels for mobile services and compare these levels with the other characteristics. The variables for measuring technology anxiety are adapted from the research instrument of Niemelä-Nyrhinen (2007).



## 2.3 Research platform

The researchers have made a preliminary list of the relevant variables for conducting the market segmentation for the baby boom generation concerning mobile services. Though the variables reflect the literature review, they are tailored to the Finnish mobile services market for baby boomers. The items are shown in Table 1

Table 1- Preliminary variables for segmenting the mobile services market for baby boomers

Variables	Labels	Sources
<b>BABY BOOMERS' CHARACTERISTICS</b>		
Age	C1	Oates et al. (1996)
Gender	C2	Oates et al. (1996)
Educational level	C3	Oates et al. (1996)
Yearly income	C4	Oates et al. (1996)
Working status	C5	Oates et al. (1996)
Reasons for working	C6	Gilbaidi (2013)
Reasons for retiring	C7	Migliaccio (2013)
Number of children	C8	Oates et al. (1996)
Marital status	C9	Oates et al. (1996)
Type of phone	C10	Statistics Finland (2013)
Experience in using the Internet	C11	Statistics Finland (2013)
Experience in using the mobile Internet	C12	Deloitte (2014)
I feel younger than my numerical age	C13	Gilbaidi (2013)
<b>MOBILE SERVICES USAGE</b>		
I use my mobile phone for calls and SMS	M1	Sell et al. (2014); Deloitte (2014)
I use my mobile phone for checking e-mails	M2	Sell et al. (2014); Deloitte (2014)
I use the calendar function in my mobile phone	M3	Sell et al. (2014)
I need my mobile phone for searching information (e.g. Google)	M4	Sell et al. (2014)
I need my mobile phone for navigation services (e.g. GPS, reittiopas)	M5	Sell et al. (2014)
I use my mobile phone to check the Internet for things related to my health	M6	Migliaccio (2013)
I use my mobile phone for communication in social networks (e.g. Facebook, Whatsapp)	M8	Grable (2013); Deloitte (2014)
I need my mobile phone for online banking (e.g. check accounts, pay for bills)	M9	Statistics Finland (2013)
I need my mobile phone for online shopping	M10	Statistics Finland (2013)
I use my mobile phone for ticketing services (e.g. pay for parking, train tickets)	M11	Mallat et al. (2009)
I use my mobile phone to watch TV	M12	Statistics Finland (2013)
I have mobile services that require monthly/yearly subscriptions (e.g. newspapers, Spotify, Netflix )	M13	Bresnahan et al. (2013)

<b>ATTITUDES</b>		
I avoid using mobile services because they are not familiar to me*	A1	Niemelä-Nyrhinen (2007)
“Mobile services” term is a confusing concept to me *	A2	Niemelä-Nyrhinen (2007)
I consider mobile services useful for my daily routines	A3	Venkatesh et al. (2012)
Using mobile services increases my productivity*	A4	Venkatesh et al. (2012)
It is easy to learn how to use mobile services	A5	Venkatesh et al. (2012)
To become skillful at using mobile services is easy *	A6	Venkatesh et al. (2012)
My important ones (e.g. friends and families) believe I should use mobile services	A7	Venkatesh et al. (2012)
It is easy to get access to mobile services I need	A8	Venkatesh et al. (2012)
I can get help from others when I have difficulties in using mobile services *	A9	Venkatesh et al. (2012)
I feel good when using mobile services	A10	Venkatesh et al. (2012)
Mobile services are reasonably priced *	A11	Venkatesh et al. (2012)
I am addicted to using mobile services*	A12	Venkatesh et al. (2012)

\* Statement composed to fit the mobile service context

### 3 METHODOLOGY

Having the necessary segmentation bases, we need to find an appropriate segmentation method. This chapter will support the second research objective.

#### 3.1 Choosing segmentation methods

Punj and Stewart (1983) noted that integrating Ward’s minimum variance method and K-means cluster analysis is recommended. First Ward’s minimum variance method is adopted to determine the initial information, i.e. starting points and number of clusters. Then it is possible to obtain centroids of clusters and refine the data, i.e. eliminate outliers. Having that information, K-mean can be used for determining the final cluster because there are no autonomous procedures in obtaining those data for the K-means method.

Bloom (2004) found that the artificial neural networks (ANNs) perform segmenting better than the traditional method in terms of (1) *not significant affected by missing values*, and (2) *not require various assumption of data distribution*. Among the ANNs, Kohonen’s self-organizing map (SOM) is used widely as a multilayer neural network for segmentation (Kohonen, 1988). Therefore, SOM can be an alternative way to conduct segmentation (Bigné et al., 2010).

In addition, Kiang et al. (2005) suggested that SOM, as a non-statistical procedure, is less sensitive to sampling variation and more robust with even small sample size. Thus, it can produce more accurate estimates.

Despite some advantages of emerging methods, such as latent class analysis (for example see Sell et al. (2014)), K-means will be used for segmenting, because it is still a standard for segmentation in market research (Sell & Walden, 2012). In addition, SOM can be used before K-means cluster analysis, in order to help defining the optimal number of clusters.

### **3.2 Data collection**

The work of segmentation will be done based on the collected data from a primary source, because the required information for conducting the study is not available (Kumar, 2011). The data will be collected via a research instrument, i.e. a questionnaire.

The questionnaire consists of three parts. In the first part, the respondents are asked for several individual characteristics. In the second part, the questions involve the use of different types of mobile services. In the third part, we ask respondents for their attitudes toward the use of mobile services.

The baby boomer characteristics are collected as categorical variables. In addition, Likert attitudinal scales will be used in order to measure the spread of the attitudes as well as the frequencies of using mobile services. The constructs of the attitudinal scales in the questionnaire reflect the literature review.

A seven-point Likert scale will be used for collecting the attitudes. The anchors are graded on 7-point Likert scale where 7 = always/ completely agree, 1 = never/completely disagree, and 4 = don't know/ neither agree nor disagree.

The empirical data will be collected through a web-based questionnaire which is mailed to members in a retirement association in Finland. It is expected that the authors can have access to 19300 e-mails of senior citizens. Most of them speak Swedish as their first language and are retired. However, some still continue working. As a result of this, the instrument will be translated to Swedish. Moreover, the instrument can be checked for validity and reliability using a test group. The test group, which should contain people who are similar to the population in the study, can help to examine which statements make sense and which ones do not.

The sample size will be enough at 1300, according to a previous similar study by Sell & Walden (2012). Therefore, we can select a subset from the total population, using a simple random sampling method. An encouragement such as promotion should be considered in order to increase the response rate. The respondents will have one week to fill in the questionnaire, in order to increase the reliability of the research instrument.

## 4 EXPECTED RESULTS & FUTURE WORK

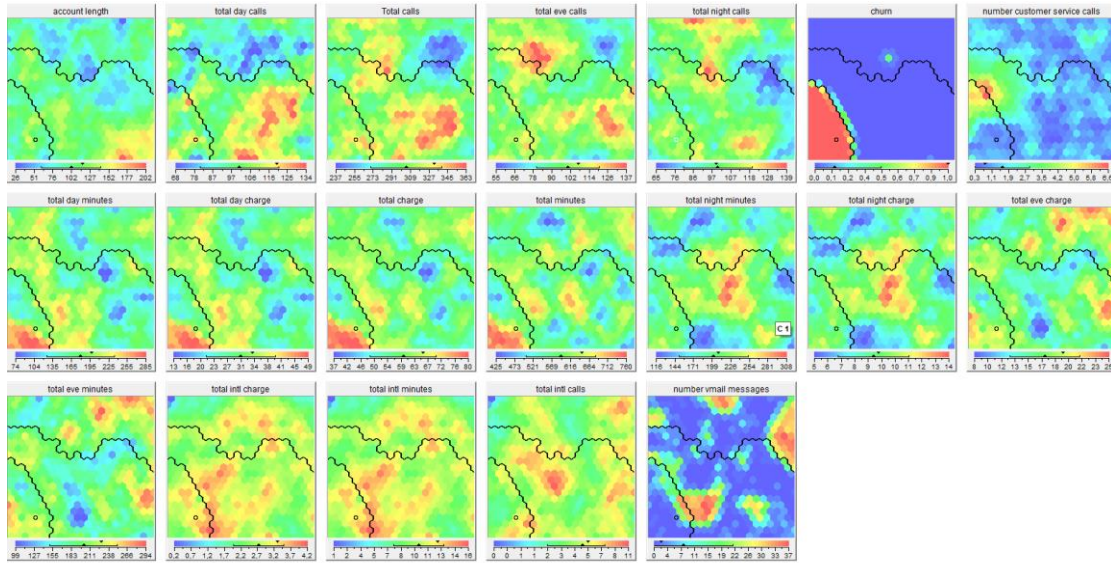


Figure 3- An example of market segmentation using SOM for 19 variables

Fig.3 shows an example of the result of segmentation using SOM via Viscovery software. The figure shows the 19 two-dimensional plots, due to the availability of 19 variables. There are three segments which have the distinct characteristics.

We are expecting to get a similar clear result from the study. If necessary, factor analysis can be used before SOM for identifying underlying variables. The result can be used as an input to the K-means method, in order to confirm the final cluster solution.

However, identifying clear segments is not emphasized for segmentation in a new emerging market such as the mobile services market. Instead, researchers should focus on dealing with complexity and ambiguity issues in the market (Quinn, Hines, & Ben- nison, 2007).

A long term goal in the future is to replicate the study (i.e. longitudinal study) to find out if the created segments are still appropriate. Furthermore, having the collected data, we can use other emerging segmentation methods, such as latent class analysis, and compare the results with our current proposed method by observing the correct classification rate.

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# Measuring the Effect of non-Salient Image Features - a Combined Eye Tracker and Conjoint Study \*

Peter Mildén, Michael von Boguslawski<sup>i</sup>

## Abstract

Designers use salient image elements to guide the viewing of web pages to wanted focus points. The viewer's attention is directed by the designer by using picture elements such as lines, contrast and color. Experienced designers know that also non salient image elements are important for the total viewing experience but as such they do not stick out. These image elements have a supporting role. How can their influence be measured? The eye tracker has proven itself to be a good tool to measure the attention of specific elements meant to be in viewing focus. To measure the effects of non-salient image elements the eye tracker is less well fitted. By combining in a single experimental study both the eye tracker and conjoint analysis to measure the same elements we got two different measurements of the same image elements and the results could be combined. This experimental study showed that the two methods do produce different but complementary results. Conjoint analysis can thus be an important complement to eye tracker studies due to its ability to determine the importance of also non salient picture elements which are overlooked by the eye tracker and not measurable. The experiment was done with student involvement both in planning and implementation of the experiment.

**Keywords:** Attention, salient image feature, non-salient image feature, web page, eye tracking, conjoint analysis

## 1 INTRODUCTION

A well-functioning web page is a complex mixture of text, images, icons, tables, video and links bound together with HTML, CSS, Flash or Java code. Since the programming of a web page is a laborious task demanding countless hours of programming and tests on different web browsers before it works perfectly the planning of web pages are

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speeded up by using templates that don't demand coding but still provide the visual image of the finished web page. Such templates can be done with relative ease in Photoshop. The template is thus a visual image of the final web page without the working interactivity due to its lack of HTML code. As an image such a web page template can be used to pretest the graphical user interface and thus help the designers to avoid expensive design mistakes (Norman, 2008).

Several books have been published providing design help for web page planners of the graphical user interface, see for example Veen J., "The Art and Science of Web Design" (2001) Lynch P. and Horton S., "Web Style Guide", Navarro A. and Tabinda K., "Effective Web Design" (2001), just to mention a few from a long list of similar books. The overall encompassing design- principles for web pages should according to the design guides be simplicity and ease of orientation on the page. It should not be difficult or time consuming to determine what the focus points are and where to click to go to the next page.

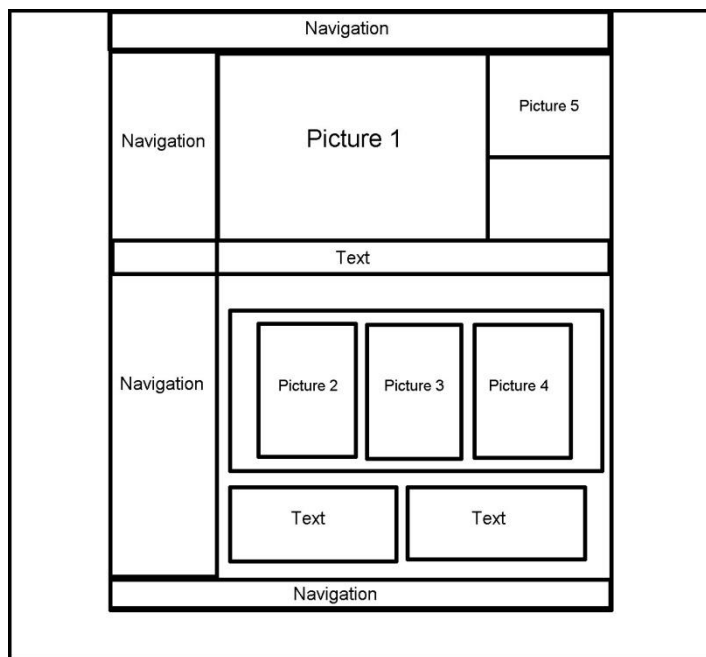
Below is a chart of a typical web page and its elements named in the square blocks. The chart describes a web page for a shop selling clothes. The main planned focus areas are the product pictures numbered from 1 to 5 illustrating where the pictures of the clothes the shop sells will be placed. The first product picture is larger as it also contains the heading for the web page.

Traditionally the navigation bars are to the left and above and below the main focus areas. The main text areas are on this web page below the product pictures. The text areas are rather small since the main focus is directed to the product pictures. The area outside the area comprising the navigation bars and picture elements is the background. Advertisements can be placed in picture area 5 and on the background.

A salient image area can be defined as something that sticks out- or attracts the viewers' attention. In this web page it is the product pictures, text areas and navigation bars that are salient. They should attract the attention of the viewer. A non-salient image area is something that doesn't attract attention to it but still is in the image. In this web page it is the background area.

Traditionally the designers have focused most of their attention on the salient areas. This is understandable, since these areas are the most important parts of the image from a commercial point of view. (Land and Tatler, 2009)





*Figure 1: A typical modern web page lay-out, the lay-out is also used in the experiment in this article*

Traditionally web designs have been tested by using questionnaires or interviews after having shown the web page to the test persons asking them to state what salient image features they have viewed or which they can recall. However, research based on questionnaires or interviews depends on the person's memory and ability to interpret his own behavior. Typical for such "ex post" research is that a respondent can always give a rational explanation for his viewing behavior due to a weak visual memory. (Norman, 2008)

The eye tracker, however, provides an unobtrusive way to measure how a person looks at the images on a web page. The recording takes place during the actual viewing process. The measurements are live recordings of the actual viewing behavior. The eye tracker records both saccades and fixations. The saccades occur when the eye moves from one point to another over the web page, when the eye movement stops a fixation occur. It is during this moment of fixation that a person collects information about the web page. Only a small part of the information collected during a fixation is used for conscious analysis by the brain. During the quick saccades when the eye moves from one fixation to another, no information about the web page is collected; a person is thus effectively blind during this moment. (Holmqvist et al., 2011)

The eye tracker recordings can visually be presented as saccades and fixations for qualitative analysis. A saccade is presented as a line and the fixations as circles. The size of the circle also indicate the time length of the fixation, a larger circle indicates a longer fixation. The scan path, see chart below, for one person shows where the viewing enters the webpage and how the eyes move over the web page as a continuous line with circles indicating the fixations. The scan path clearly shows that the viewing has progressed first in a linear way as reading a book page and then in an irregular fashion.

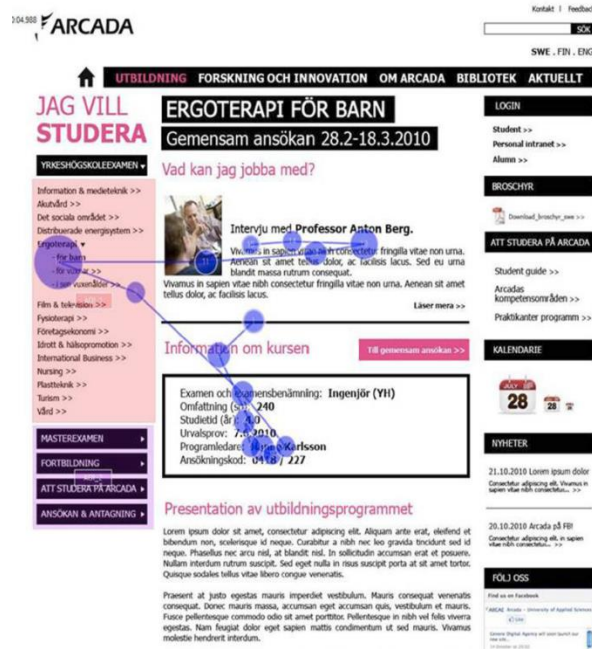


Figure 2: Eye tracker results presented as a scan path with fixations as circles

The heat map in the image below shows the concentration of fixations on different web page elements. The red areas of the heat map show those image elements that attracted the most attention and are interpreted as the most salient ones. On a well-planned web page the heat maps should coincide with the planned focus areas, otherwise ‘distracting’ elements are present on the page, which disturbs the communication.

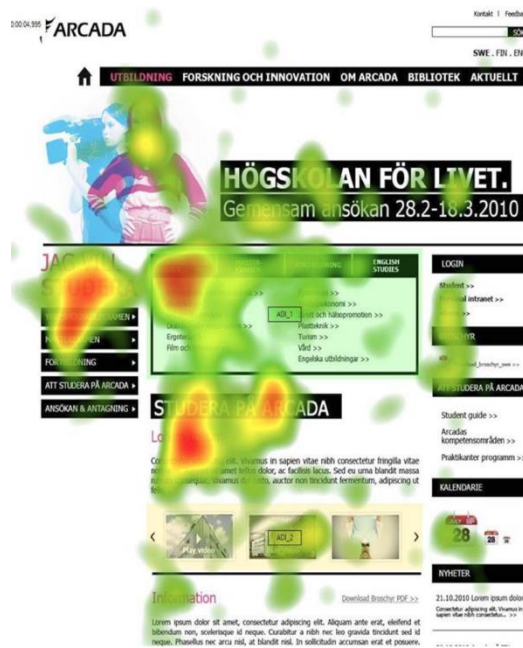


Figure 3: Eye tracker measurement results showing heat maps or salient web page elements

The interpretation of the heat maps as showing salient image areas is based on the build-up theory of attention. The theory starts by noting that it is the features of the image that accounts for the attention directed towards it. (Snowden, Thompson and Troscianko, 2006) In advertising quite a large amount of research has traditionally been directed towards determining how to create images that draw attention towards themselves. The research has tried to answer how image elements such as color/ no-color, relative size, different fonts, pictures/ no-pictures, surprising or shocking pictures attract attention to itself. Measurements have been done with unaided and aided recall of images and messages. (Purvis, 2010)

The top-down theory of attention states that attention is determined mainly by a search of relevant information to solve a task or problem at hand. Information about web page is collected based on its utility in helping to solve the problem. Other information can also attract attention momentarily but is quickly disregarded as irrelevant or being harmless.

Yarbus (1973) has clearly shown that the viewing of an image and the resulting scan paths differ considerably depending on the task given to the viewer. In a famous experiment Yarbus showed the same picture to the test persons but gave them different assignments. The resulting scan-paths were quite different depending on the task given. In this case the attention was thus clearly top-down guided by the task given. The top-down theory of attention also explains to some extent the blindness for obvious image elements that have not been seen, i.e. selective blindness.

The eye tracker is very good at measuring different elements of a web page that attract attention. Each visual element which is strong enough to draw attention to it is measured. Such a salient stimulus can be determined by a scan path leading to it, by the number of fixations on it, or by the length of the fixations.

By determining special areas of interest on an image, AOIs, the eye tracker allows statistical information to be collected. The eye tracker is thus a good tool at determining the salience of *a priori* determined elements in an image. This statistical data can be exported and used for further statistical testing. (Holmqvist et al., 2011)

Some image elements are important but they are not intended to be at the focus point of viewing. The role of such non salient elements is only to emphasize the focus points, to make the focus point's impact stronger. An artist painting a portrait does not start by painting the face, but by painting the background color. Without first painting the background color the colors of the face cannot be correctly determined and painted. The perception of a color is strongly influenced by its background. (Berger, 1990)

In summary, the eye tracker measures well elements that are in the focus of viewing by measuring saccades and fixations, and by showing how the viewing proceeds with scan paths and salient image features with heat maps. Image elements that don't attract viewing or fixations are not measured, or visualized by the eye tracker. How can then the importance of non- salient image features be measured that clearly constitute integral visual elements in a complex image? Clearly some other measurement method must be used that allows the determination of the value of such image elements. Conjoint analysis could be such a method. Conjoint analysis starts with a complete image, or product,

and then decomposes it in order to determine the importance of each specific element. Conjoint analysis is thus a decomposition method. (Rao, 2014)

Conjoint analysis does not ask a respondent to evaluate each image feature individually, just to rank different complete images and then infers the importance of each image feature based on the ranking or preference. In this way the method resembles a real choice situation where the respondent has to view different images and rank the images in preference order from most preferred to least preferred.

A small scale experiment was done on a web page template modified by using conjoint analysis. The resulting web pages were measured both with the eye tracker and with conjoint analysis.

The assumptions, or hypothesis, of this exploratory experiment was that the eye tracker would clearly measure the salient features of the web pages such as product pictures, navigation bars and text areas. What measurements the eye tracker would provide for the background element could not be determined a priori and were thus left to empirical observation.

The conjoint analysis was expected to give importance measurements both of the salient and non-salient web page elements. Their relative importance was, however, a priori difficult to determine. The conjoint analysis would determine the importance of both elements but lacks the detailed information about the scan paths and the fixations

## **2 METHOD**

For the experiment a professionally made Photoshop template for a web shop selling clothes was used as a starting point. The Photoshop template was chosen because its layered structure made it possible to change different web page elements and then save them as new web pages. The basic structure of the web page was very traditional, with navigation bars on the left, top and bottom, and the picture and text elements in the middle. A schematic lay-out of the web page was given in the sections above. A web shop selling clothes was chosen as most participants were assumed to have some familiarity of buying clothes online. The template for the web shop was presented as different jpg images, without any HTML code. No menus or other web page elements were thus functional. The main task was limited to judge the web pages as images. Two variables were changed in the web page templates: the pictures showing the products and the background colors around the main focus area.

A study of some well-known web shops selling clothes indicated that the dominant background colors at that moment were black, white and purple. These three colors were consequently chosen as the background color alternatives. Two types of product pictures were used, pictures showing only clothes or clothes dressed on persons. The background colors of the large Picture 1 were also changed to reflect the color theme of the background color. Equally, some of the background colors of the menus were also

changed to better reflect the color themes. The text areas surrounding the three smaller pictures were kept white.

Different web page alternatives were made using the SPSS conjoint algorithm for producing orthogonal designs<sup>5</sup>. (See the footnote for a short description of the conjoint method.) In total six different web pages were determined by SPSS by changing the picture elements. The table below shows the 6 different web pages created by SPSS and the combinations of the picture elements. Strictly speaking, the use of SPSS would not have been necessary with so few elements, but the analysis was greatly simplified by using SPSS. Thumbnails of the web pages are presented below. (SPSS, 1998)

*Table1: Web images and their elements produced by the SPSS orthogonal algorithm*

Webpage	Background color	Type of picture
1	Black	With person
2	Black	Only clothes
3	White	With person
4	Purple	With person
5	White	Only clothes
6	Purple	Only clothes

The final web page images used in the experiment are shown below.

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<sup>5</sup> Conjoint analysis is decomposition method. The method does not ask the respondent to evaluate each product feature individually, just to rank different complete products and then infers the importance of each product feature based on the ranking. In this way the method resembles a real choice situation where the customer has to choose between different products.

To implement the conjoint method firstly, product features and their levels are determined by the researcher. These features will vary between products; other features can be included for reality but they are regarded as constants because they don't change between products. Color was in this study such a feature and it had three levels; black, white and purple. Then an orthogonal design is made by making complete products, or product profiles, with the specified features and levels with SPSS. An orthogonal design does not make all product combinations but a smaller amount according to an experimental design. Values for the missing product combinations are later calculated by SPSS. Secondly, the respondents are asked either to rank the different products from the most preferred to the least preferred, or to grade them on a Likert scale. By using a form of dummy coding and regression analysis SPSS calculates for each person the weights that each product feature shall be given in order to replicate the ranking or grading. The calculated weights indicate the person's part worth's or utilities associated with each product feature and its levels. For the whole sample summary statistics; the utilities of different product features and their importance are given. (Rao, 2014)



Figure 4: Web pages constructed with the help of the SPSS orthogonal design module

The study consisted of two parts. Initially, the 6 web pages were shown to the participants as images using the Tobii T-120 eye tracker and the fixations on each web page were recorded.

The respondents were instructed to evaluate proposals for new web pages and asked to focus their attention on the product photos. Nothing was said about the background. No time constraint was imposed – the participants ended the session with a mouse click anywhere on the screen when finished.

The two main areas of interest were the product pictures and the background areas. Both the total number of fixations and the total visit duration were recorded. At the end of the trial, all six pages were shown simultaneously on one page.

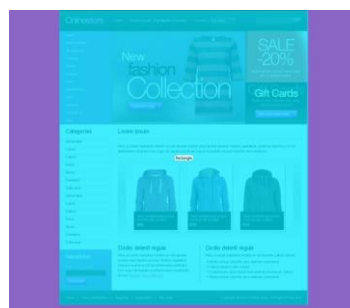


Figure 5: Definition of areas of interest. (Turquoise= pictures, purple= background)

More specific numeric information concerning the fixations was obtained by defining two Areas Of Interest (AOIs); the first area of interest defined the picture elements and the second the background elements.

The second part of the experiment included a questionnaire. After the eye tracking trial, the participants were asked to fill in a simple questionnaire. The questionnaire had thumbnail pictures of the web pages and the respondent were asked to both rank the six web pages from the most preferred to the least preferred and also to indicate his/her liking of each web page on a Likert scale by assigning numbers ranging from 0 to 100. Ties were allowed and it was not mandatory to use the whole scale. The study was done as an exercise on a course in product development at Arcada for bachelor students. All respondents were given the same instructions, and the pictures were shown in the same order on the eye tracker. A total of 36 persons participated in the experiment, 69 percent being females and 31 percent males.

Seventeen percent of the respondents bought most or half of their clothes online and 64 percent sometimes or seldom and 19 percent never bought clothes online. Most respondents thus had some experience of online shopping of clothes.

### **3 RESULTS**

#### **3.1 Eye tracker measurements**

A first visualization of the results of the eye tracker study is shown below as heat maps for each web page summarizing the fixations for the whole sample of participants. The heat maps clearly show the concentration of fixations to the products on the web pages, indicated by the red dots. Some fixations were concentrated on the menu at the left and on the text elements of the web pages, indicated by the yellow and green colors. The heat maps do not explicitly show any concentration of fixations on the background elements.

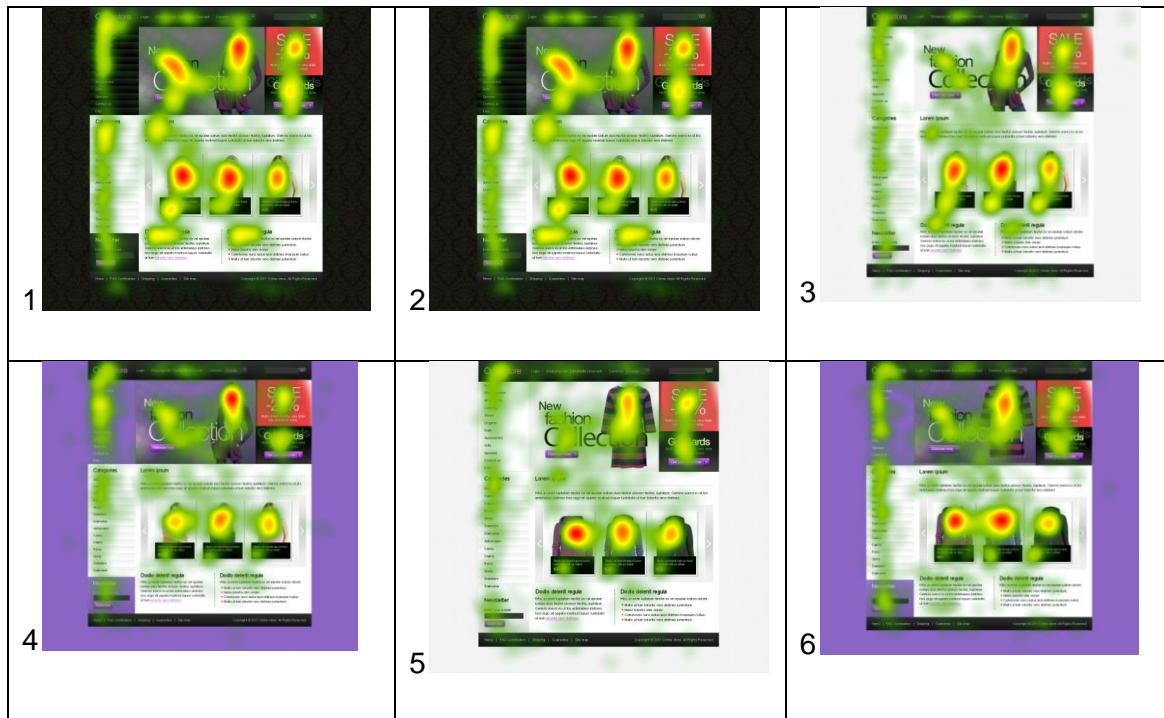


Figure 6: Heat maps showing concentration of fixations on the six web pages in the experiment

According to Yarbus (1973) such a result was expected as the task given to the participants of the experiment was to concentrate their attention on the product pictures. The top-down attention was through the given task directed to the product pictures.

By determining the AOI areas, statistical data concerning the visit duration could be obtained. The data for visit duration showed that almost all participants looked at the product pictures (N= 35), with the average viewing times ranging from 14 to 8.5 seconds, but with large variations in viewing times; the standard deviations for the viewing time ranged from 10.5 to 6.8 seconds.

The first web page had the longest average viewing time with 14.0 seconds with decreasing visit durations for the following web pages. This decreasing viewing time was probably due to the similarity of the stimuli combined with a learning effect.

Data concerning the background elements showed that it was not ignored by all participants. A smaller amount of participants looked at the background consciously or unconsciously with N ranging from 25 to 13. The viewing was quicker, just glances with lower average viewing times ranging from 1.5 to 0.6 seconds, and smaller standard deviations ranging from 2.1 to 0.4 seconds. It should be remembered that viewing involving only the peripheral vision was not recorded by the eye tracker. A lack of fixation measurements did not necessarily mean that an element was completely unnoticed.



Table 2: Visit duration on two areas of interest- times looking at the focus area and the back-ground for each of the six web pages

	P1 Pic- tures	P1 Backgr tures	P2 Pic- tures	P2 Backgr tures	P3 Pic- tures	P3 Backgr tures	P4 Pic- tures	P4 Backgr tures	P5 Pic- tures	P5 Backgr tures	P6 Pic- tures	P6 Backgr tures
Mean	14.0	1.5	10.1	.9	10.1	.8	8.6	.7	8.5	.6	8.7	1.0
Std.Dev	10.5	2.1	7.1	.9	8.3	1.2	6.8	.5	8.9	.4	10.1	1.5
N	34	25	35	15	36	16	36	15	36	17	35	13

Summarizing the results of the eye tracker measurements we can say that the eye tracker was able to measure the main elements of the web page image. Attention was also given the heading in Picture 1 and on Picture 5. The red picture in the upper right corner was a clear distraction drawing attention to it. The visualization tools of the eye tracker did not show any fixations on the background AOI. Only the statistical data showed that there were actually fixations, albeit short ones, on the background elements. A conclusion based only on the eye tracker data would suggest that the background properties of the images were of low importance.

### 3.2 Conjoint measurements

The results of the conjoint ratings of the web page images are shown in table 3 below. A respondent was free to indicate his liking of a web page by grading it on a scale from 0 to 100. The mean ratings ranged from the highest 75.0 to the lowest 43.1. The standard deviation ranged from 25.5 to 20.2. No statistically significant differences could be observed between ratings done by men and women when tested by ANOVA. The differences in ratings were, however, statistically significant.

Table 3: Mean ratings of web pages

	N	Mean	Std. Dev.
1	36	61.6	23.0
2	36	51.7	23.6
3	36	75.0	20.2
4	36	50.5	25.6
5	36	61.3	23.0
6	36	43.1	24.7

The SPSS conjoint algorithm calculated the utilities, for each person individually associated with the pictures and the background elements. The calculations were done by SPSS by using dummy variables for the picture elements, as the independent variables in the analysis and by using the rating scores as the dependent variable. For each person there were thus 6 equations to determine values for 5 independent variables. The SPSS conjoint analysis module, by using regression analysis, thus calculated for each person the weights that implicitly should be given to each picture element in order to reproduce the person's ratings. (SPSS, 1998, Rao, 2014)

Based on the individual utility calculations the conjoint analysis module in SPSS also gave summary output either for larger groups or for the whole sample. In table 4 the summary statistics are shown for females and males independently. The results on a group level showed that the most important feature was the background color accounting for 65.4 per cent for females to 73 per cent for males of total utility. The importance of the product pictures had a utility of 34.5 per cent for females and 26.9 per cent for males. Clearly the product pictures had lower utility values calculated by conjoint analysis when the web pages were judged as complete entities.

Looking at the image elements individually the product pictures with persons had a higher utility value both for females and males compared with the ones without a person. For females the utility was 5.7 and for males 3.7 for product pictures with a person included. Equally, the utility values of the background color was the highest for the white color, black's utility being close to zero and the lowest utility had the purple color.

Table 4: Summary utilities for females and males

<b>Utilities<sup>a</sup></b>				<b>Utilities<sup>a</sup></b>			
		Utility Estimate	Std. Error			Utility Estimate	Std. Error
Color	Black	.253	2.035	Black	-2.409	.390	
	White	10.153	2.035	Color	White	12.773	.390
	Purple	-10.407	2.035		Purple	-10.364	.390
Picture	People	5.780	1.439		People	3.742	.276
	Clothes	-5.780	1.439	Picture	Clothes	-3.742	.276
(Constant)		57.047	1.439	(Constant)		57.773	.276
a. Gender = Female				a. Gender = Male			
<b>Importance Values<sup>a</sup></b>				<b>Importance Values<sup>a</sup></b>			
Color		65.492		Color		73.007	
Picture		34.508		Picture		26.993	
Averaged Importance Score				Averaged Importance Score			
a. Gender = Female				a. Gender = Male			

For both females and males the white background had the highest utility (10.1 and 12.7) and purple (-10.7 and -10.3) the lowest utility with black close to zero (0.2 and -2.4).

## 4 DISCUSSION AND CONCLUSION

This study tried combining two quantitative methods for solving an empirical design problem in an experimental setting: How to measure the importance of non-salient image elements. The eye tracker has successfully been used in several a priori tests of visual communication to determine where the focus is and thus measures salient image features well.

By using conjoint analysis it became possible to determine the utilities, or importance values, of all image elements specified by the researcher a priori, also of the non-salient image elements. The limitation imposed by the conjoint analysis is an empirical one; during the creative image development process only a priori determined image elements could be changed. If the designer is free to change all image elements based on his free creative will it becomes impossible to determine the image elements' effects.

The human face is a symbol that always elicits strong interest in viewers. (Zakia, 2013) A priori a product picture with a human face draws more attention than one without a face, which the eye tracker measurements clearly showed. The clear focus on the products was expected as the instructions given to the participants clearly stated that they should explicitly look at the product pictures. The conjoint analysis gave another quantitative measurement of the difference between the two product pictures. The conjoint analysis showed a high degree of congruence between females and males for the product pictures with the human face. However, in certain circumstances the human element could be a distracting one. For analyzing a image elements clearly intended to be in the viewer's focus the additional value of using conjoint analysis is rather limited.

However, the value of conjoint analysis was emphasized when the importance of non-salient features such as background color was to be determined. The eye tracker clearly indicated quick passing fixations on the background as such. Because the colored fields were void of any additional information the viewing was expected to be quick. Viewing with the peripheral sight could not be measured by the eye tracker. Only the conjoint analysis was able to determine the large relative importance of the background color. This gives a strong argument to use conjoint analysis in connection with eye tracker studies. The background color was also the picture element that showed the largest individual differences in utilities.

Neither was it surprising that the white background had the highest utility. The normative web design literature recommends the use of black text on plain high-contrast non-patterned background. The reading speed could be up to 32 per cent faster. (Dept. of Health and Human Services, 2006) The results of this small experiment as such were not surprising. The most interesting results were on the methodological side solving a problem how to measure the value of non-salient image features.

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# Decisions and Choices

Eldon Sveinn<sup>i</sup>

## Abstract

This short report is a study of the process of application for a study place at a university. Eighty business students were interviewed about why they decided to study at a university, and how they went about selecting a country, town, university, and a subject. Who and what influenced them during their selection process was investigated. The findings are displayed using graphs, analysed, and finally some recommendations are given.

**Keywords:** Applying, influencers, university, internet, time, social media, sources of information, location, selecting, language of instruction.

## 1 INTRODUCTION

The competition between universities for good student has increased in recent years. The number of universities has increased and so students have more universities to choose from. This makes it important to know, what attracts students to study at a university, and why they choose one university rather than another. But recruiters have to know more, they have to understand the whole selection process. The process starts with the pupil becoming aware of the possibility of continuing to study after secondary school, to a firm resolve to do so, to choosing a university, and applying to more than one university, and finally accepting an offer of a place to study. This abridged study is intended as a small contribution to understanding this complex process.

### Methodology

The author interviewed eighty students at Arcada University of Applied Sciences, during the autumn of 2013 and spring of 2014. All the students studied in the International Business Programme. They were asked to answer a few questions. All the questions were open ended and the students wrote the answers down in their own good time, often at home using their own words. No student wrote his answers in the presence of the au-

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thor. The answers were not anonymous, but the identity of the students is not revealed in the results. Most students answered all fourteen questions.

The range of answers to most of the questions was surpassingly limited, which made it possible for the author to display the results as graphs, even if that had not been the author's plan. The answers are analysed and briefly discussed.

## 2 RESULTS AND ANALYSIS OF INTERVIEWS

Question 1. Why did you decide to study at a university?

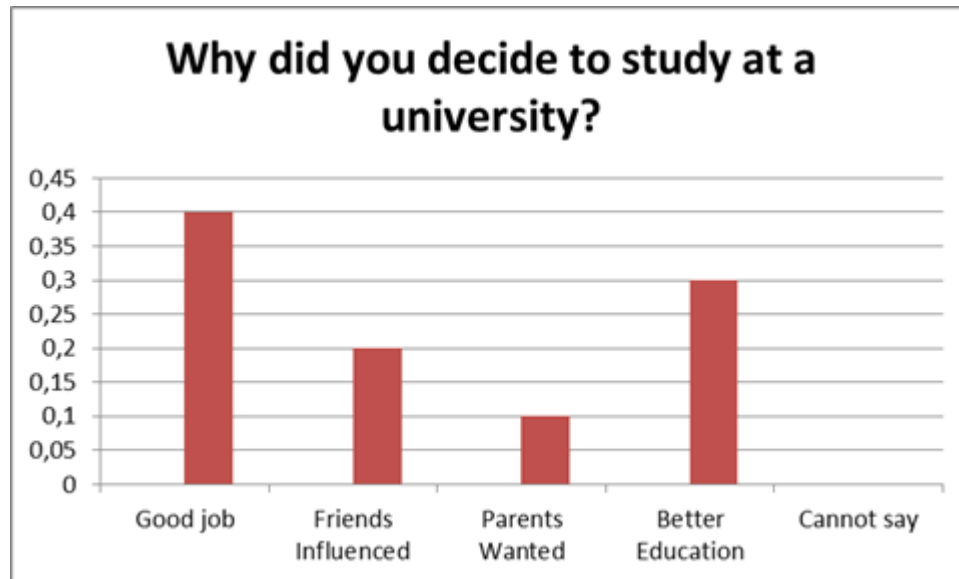


Figure 4

Many of the respondents seem to have given the answer that has come first to their mind. Forty percent of them replied that they wanted to make it possible for them to get a good job. This is a typical extrinsic motive, for why indeed would anyone want to study business administration except in order to get a job? (Baumeister 1999) Yet most of the students gave a different reason. Possibly the students are here revealing their need for both financial security and esteem (Baumeister 1999).

Slightly more than twenty percent stated that the reason was that their friends studied at a university, and they did not want to be different from their friends in this respect. Their friends had not encouraged them to study, and they had not (except in three cases) applied for admission at universities where their friends studied, but they did not want to be "any less" than their friends, so they studied too. This is perhaps best explained as an effort by these students to keep their self-esteem intact (Baumeister 1999).

Ten percent stated that it was not their decision, but they had done so on the insistence of their parents.

Over thirty percent stated that the reason was that they wanted to increase their knowledge. This is on the face of it a surprising result, given that the respondents were all business students. There was no correlation found between the students having tried to get into study other subjects and business, and this answer. The most obvious interpretation of this answer is that it is another way of saying that they want to increase

their knowledge in order to be more attractive on the job market. Another explanation is that students feel a need to actualise themselves, which would be an intrinsic motive (Baumeister 1999).

There was no clear difference here between genders or cultures, when it came to the different answers, which is surprising as one would have expected that a high number of Finnish students would have stated a good job as their main reason, and many Asian students would have stated the will of their parents. This furthermore shows that one should avoid preconceptions when it comes to determining motives.

Knowing why these students choose to study at a university, helps to understand how to motivate students who seem to lack motivation, and perhaps do not even know why they are studying at a university, see no point in it and are only doing it to please their parents or not to feel inferior to their friends.

Question 2. Did anyone directly influence your decision to study at a university?

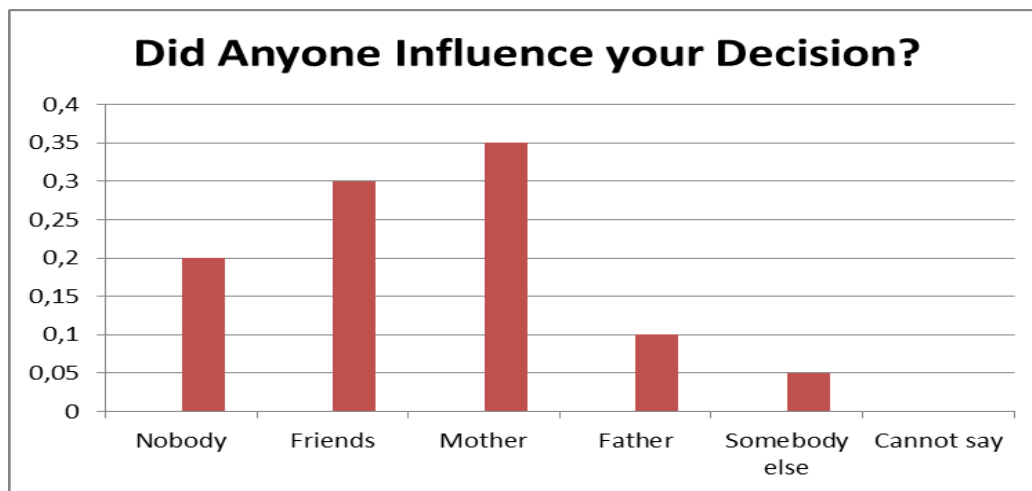


Figure 5

Question 2 was asked to double check the influence of others on the students' decision to study at a university.

Twenty percent of the students claimed that nobody influenced their decision, they made the decision themselves and without outside interference. There is no reason to doubt the veracity of the students' reply. However two factors come to play here, one is the fact that students in their teens, even in their late teens have a need to assert their independence, they do not want, or so they claim, others to meddle in their affairs. Yet at the same time, and this is the other factor, they are very uncertain, and discuss a lot with their friends and on social media. It is not unlikely that those students who claimed that they made the decision by themselves, discount the influence others on their decision, or are unaware of it (Kreps 1997) (see also Akerlof 1991).

Thirty percent answered that friends had influenced their decision directly. This response is in line with the observation made in the paragraph above, that teenagers often talk things over with their friends. An omission in this research is that the researcher did not ask the respondents to define the word "friend". Is a friend always a physical person or can he also be someone you only have met via social media? (Johnston 2010). Is a friend maybe someone you talk things over with rather than physically "hang out" with? If a friend is someone you discuss with, rather than "hang out" with, then one could have expected that a higher number of students would have answered that their friends had influenced their choice directly, for then a "friend" is by default someone who in-

fluences your choices. Another interesting aspect of this answer is that, as was pointed out above in the discussion of the answers to question one, very few of the students who claimed they had been influenced by their friends, did choose to attend the same university as their friends. But the explanations for this low frequency can be several, failure to be admitted to the university attended by a friend, or the fact that the friends are scattered all over the world, and are social media friends.

Forty five percent answered that their parents had influenced their decision. According to Maringe (2006) parents influence pupils least in their choice of further education. Yet this is hardly an unexpected answer, and in fact one could have expected it more students to give it. The parents provide the student often with food, shelter and financing, so it is likely that they have their say in an important matter like this. That the parents had their say in the matter also does not rule out that other parties, like friends, influenced the decision as well.

There is a sharp difference however between the influence of the father and of the mother. Thirty five percent of the students claimed that their mother influenced them, but only ten percent claimed that their father did. This is in accordance with the findings of Johnston (Johnston 2010) who found that mothers influence their children more in the choice of education than other parties. Johnston found that fathers ranked as the fourth most influential party (Johnston 2010). The reasons for this difference in influence between the parents can be several. The parents can be divorced, and the students living with their mother. The father can be deceased, etc. The likeliest reason, however, is the differences in their gender. Sixty seven percent of the respondents were females, and girls may possibly rather discuss important matters over with their mother than with their father. Mothers may also address matters of their children's future more often and more concretely than fathers, who often see everything to do with their children as an issue which the mother should deal with. This, however, is only guesswork, and the author has not found any research to back this thesis up.

Only five percent of the respondents claimed not to have been influenced directly by their school teachers. This is a surprisingly low number for according to Maringe (2006), teachers influence pupils more in their choice of university than any other party. One would, therefore, have expected teachers to play a greater role. But this is in accordance with Johnston's findings (Johnston 2010). Johnston found that teachers and other school staff influence their pupils choice little or not at all. The answer could be that today teachers refrain from mixing in their pupils' choice. But this could also be a reflection of the change in the teachers' role from an authority to a learning supervisor. Pupils have now easy access to information through the internet. Another possible reason could be that a number of those students who claimed that no one influenced their decision, were influenced by their teachers encouragement to study more. As study attainment are perceived by the pupil as his own achievement, and all comments made by the teachers concerning further study are regarded as comments on those study attainment, a student may not see it as an attempt to influence her future plans, but only a comment on her past study performance.



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# Electronic Nose Technologies

Kaj Grahn<sup>i</sup>

## Abstract

A brief introduction to the current state of electronic nose technologies is presented. Research and development on real-time human odor detection and classification has accelerated at a fast pace during the last two decades. Electronic nose technologies covered in this article include sample delivery, detection and data computing. Electronic noses have a clear potential to be a non-invasive, simple, rapid and accurate human odor detection and classification tool.

**Keywords:** detector, electronic nose, human odor, sensor, spectrometry

## 1 INTRODUCTION

The use of odors to detect diseases can be traced back to ancient times. Diabetes was diagnosed from the sweet taste of glucose in urine and ketoacidosis was suspected from a smell of acetone in the breath. A foul smell is often present in infections. Dogs have demonstrated excellent performance in different clinical discrimination tests. The odor is caused by volatile organic compounds (VOC) in the surrounding air.

Can we measure a smell? Scientist Alexander Graham Bell said the following:

*“Did you ever measure a smell? Can you tell whether one smell is just twice strong as another? Can you measure the difference between two kinds of smell and another? It is very obvious that we have very many different kinds of smells, all the way from the odour of violets and roses up to asafetida. But until you can measure their likeness and differences, you can have no science of odour. If you are ambitious to find a new science, measure a smell.”*

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The electronic nose is designed to mimic mammalian olfaction (Chen, Wang and Choi, 2013). The device comprises of an array of sensitive sensors, a signal-preprocessing unit and a pattern recognition system, i.e. a characteristic fingerprint is recognized and compared with previously recorded patterns. New technique for mimicking human olfactory is under development. The wanted result is noninvasive, simple, rapid and accurate handheld tools.

This brief review describes the working principle of electronic noses. Sample delivery, detection and data computing are discussed.

## 2 WORKING PRINCIPLE OF THE ELECTRONIC NOSE

Technologies, referred to as electronic noses, are capable to detect and recognize odors and flavors, i.e. the technologies are designed to mimic the working principles of mammalian olfaction. In (Roine, 2014), the term electronic nose is defined as an array of chemical sensors with different selectivity, a signal-preprocessing unit and a pattern recognition system.

The array of sensors interacts with volatile organic compounds (VOC) and generates a characteristic fingerprint, which can be recognized by comparing it with previously recorded patterns in the recognition system. A unique aroma signature pattern may be determined without having to separate the mixture into individual components prior to or during analysis.

In a more general description (Chen, Wang and Choi, 2013) an electronic nose device is composed of three systems: 1) a sample delivery system, 2) a detection system and 3) a data computing system.

### 2.1 Sample delivery system

The delivery system sends volatile compounds into the detection system. The goal of this pretreatment step is to enrich, clean up and enhance the signal. There are three different types of delivery systems (Chen, Wang and Choi, 2013), (Roine, 2014):

**Static Headspace extraction.** In the delivery to the sensor, the sample is stored in a sealed container, wherein volatile compounds are allowed to build up and reach equilibrium. The headspace is removed and injected into the sensor. This step is followed by cleansing of the sensor with reference gas. Container volume, sample matrix and temperature are key factors regarding the sampling's sensitivity and reproducibility.

**Dynamic headspace extraction.** This delivery system reduces the sampling time and standardizes the sample concentration. The sample is exposed to a continuous flow of inert carrier gas, which carries the sample molecules to the sensor array. The dynamic headspace never reaches equilibrium due to the constant gas flow, and it also typically contains a lower concentration of sample molecules.

**Solid-phase microextraction.** A fiber coated with adsorbing molecules is introduced into the headspace, where it begins adsorbing the targeted molecules. When equilibrium is reached, the fiber is extracted from the headspace, and the sample molecules are released to the sensor array by heating. In order to achieve maximum sensitivity to a wider range of molecules a number of different coatings may be used.

## 2.2 Detection system

The sensors interact with the gas (flavor/odor) molecules through absorption, adsorption or chemical reactions with thin or thick films of the sensor material (Arshak et. al., 2004). Typical technologies are conductivity sensors, optical sensors, quartz crystal microbalance sensors (QCM), surface acoustic sensors (SAW), metal oxide semiconductor field-effect transistor sensors (MOSTFT) and ion mobility spectrometry sensors (IMS). (Arshak et. al., 2004)

**Conductivity sensors.** Most commonly utilized classes of sensing materials in conductivity sensors are conducting polymer composites, intrinsically conducting polymers and metal oxides.. Interaction with a gas/odor leads to a change in resistance in the sensor. These changes are different for each material type. Metal oxide sensors require high temperature for effective operation (high sensitivity). A typical conductivity sensor design is shown in Figure 1.

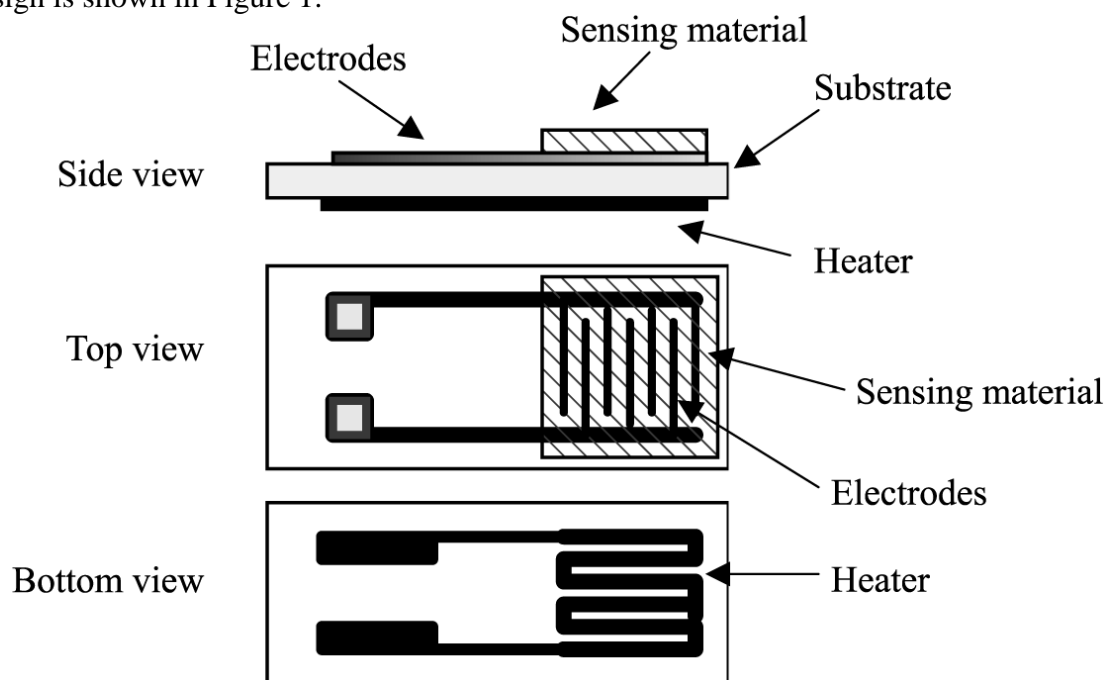


Figure 6. Typical structure of a conductivity sensor (Arshak et. al., 2004)

**Optical sensors.** The detecting system comprises four basic components: a light source, optics for directing the light, sensing materials (sensor) and a photodiode for light detecting (Chen, Wang and Choi, 2013). Optical sensors are either intrinsic or extrinsic. In an intrinsic sensor, the volatiles directly affect the optical properties of the

light wave such as absorbance, fluorescence and refractive index. Approaches applied to electronic noses include waveguides method, surface plasmon resonance, interference or reflection-based method, and scanning light-pulse technique. In an extrinsic sensor, the analyte is attached on an optical substrate. Indicators can be dyes, polymers or other materials that interact with the analyte to produce signal modulation. Sensors based on a light wave crossing a space containing volatile molecules, which alter the light signal's characteristics, are widely used. The colorimetric method is the most common. (Chen, Wang and Choi, 2013)

**Quartz crystal micobalance sensors.** The QCM sensor produces a wave that travels through the bulk of the sensor. An ac voltage applied across the piezoelectric quartz crystal starts a material oscillation at the resonant frequency. A three-dimensional wave will travel through the entire bulk of the crystal. This frequency is normally between 10 and 30MHz. A membrane deposited onto the surface of the crystal and exposed to the vapour will adsorb gas. This results in an increase in its mass and a change in resonant frequency.. This is used for the detection of the vapour. (Chen, Wang and Choi, 2013)

**Surface acoustic wave sensors.** In the SAW device the sensitive membrane is placed between two transducers and an ac signal is applied across the input transducer. An acoustic two-dimensional wave is created and it propagates along the surface of the crystal at a depth of one wavelength at operating frequencies between 100 and 400MHz. Sorption of a vapour will change the frequency.

**MOSFET sensor.** Molecules in the phase reacts at the selective layer. Products of the reactions polarize and absorb at the metal surface. Some of these products diffuse through the catalytic metal and form dipoles at the metal-insulator. A dipole layer is formed which changes the electric field between the metal and the semiconductor. Further, the field affects the threshold voltage due to changes in the work functions of the metal and oxide layers. The sensor response is measured as the change in the gate voltage of the MOSFE

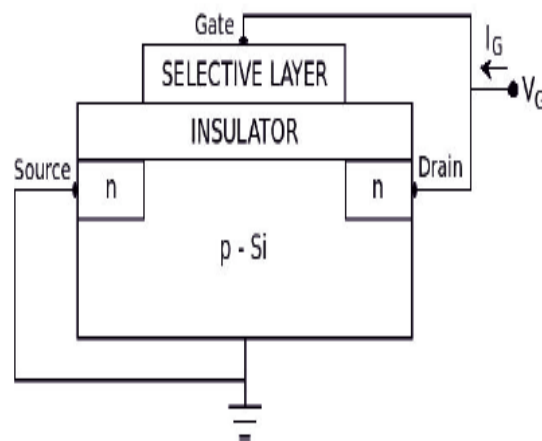


Figure 2. Electrical schema of a MOSFET gas sensor (Trincavelli, 2010).

**Ion mobility spectrometry sensors.** The drift tube design is a conventional IMS. The working principle relies on mass spectrometric (MS) time-of-flight (TOF) separation operating at atmospheric pressure. The tube consists of a reactant section with ionization source, shutter grid, drift section and ion collector, see Figure 3. Several ionization methods both radiative and nonradiative exist. The most common used drift gases are air and nitrogen. The formed ions are transferred to the drift section via the shutter grid. Analyte identification is based on drift times. Drift velocities are dependent not only on the mass of the ions, but also on their structure, shape and electrical properties. (Li, 2014)

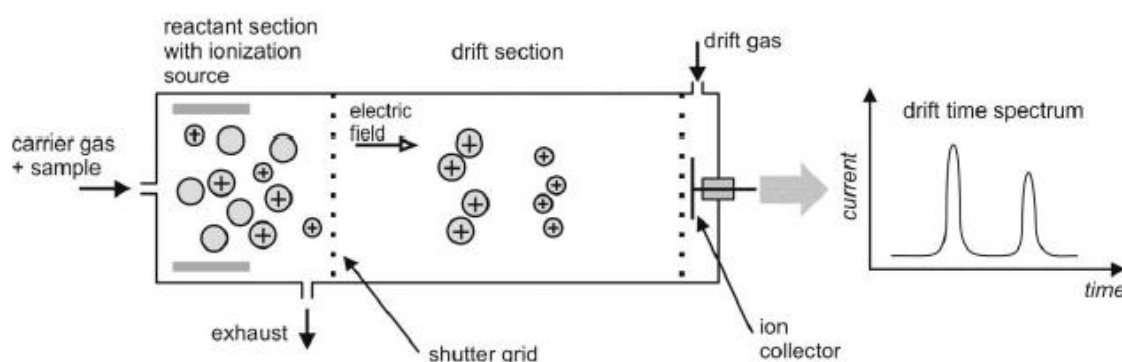


Figure 3. Principal of ISM operational drift. (Li, 2014)

IMS is a straightforward, low cost method for fast and sensitive determination of organic and inorganic analytes. Originally IMS was used in security and military applications but today there is an increased attention to environmental and biological analysis, to food quality determination and to clinical diagnosis. JMS has low power consumption and can be miniaturized as handheld devices. High sensitivity and fast response times are typical features but a drawback is sensitivity to humidity. (Roine, 2014),(Li, 2014)

A combination of IMS with metal oxide semiconductors is used in the ChemPro devices developed by the Finnish company Environics Oy, Mikkeli, Finland. [4]

### 2.3 Data computing system.

Pattern-recognition techniques are used to process the multivariate response generated by the sensor array. The sensor signals are acquired and stored by the computer. The process can be split into four stages: signal preprocessing, dimensionality reduction, prediction and validation. These stages are shown in Figure 4.

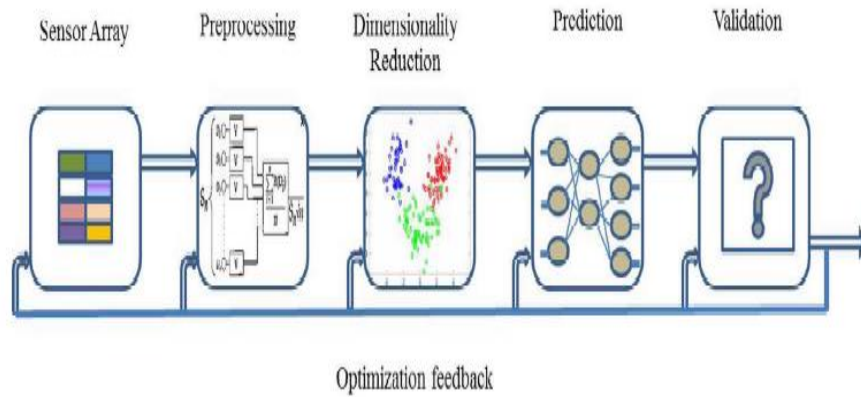


Figure 4. Four sequential stages in data processing [1].

Signal preprocessing compensates for sensor drift and extracts descriptive parameters from the sensor array response. The initial feature vector dimensionality is reduced in stage two. Data classification, regression and clustering are the following steps. Classification identifies an unknown odor sample by comparing to store data. The properties (concentration, quality) of the analytes are predicted by regression. Spatial relationships or similarities among data samples are addressed by clustering. In the validation process, models and parameter settings are selected and true error rates are estimated..

Figure 5 shows the data processing scheme of pattern analysis techniques in electronic noses.

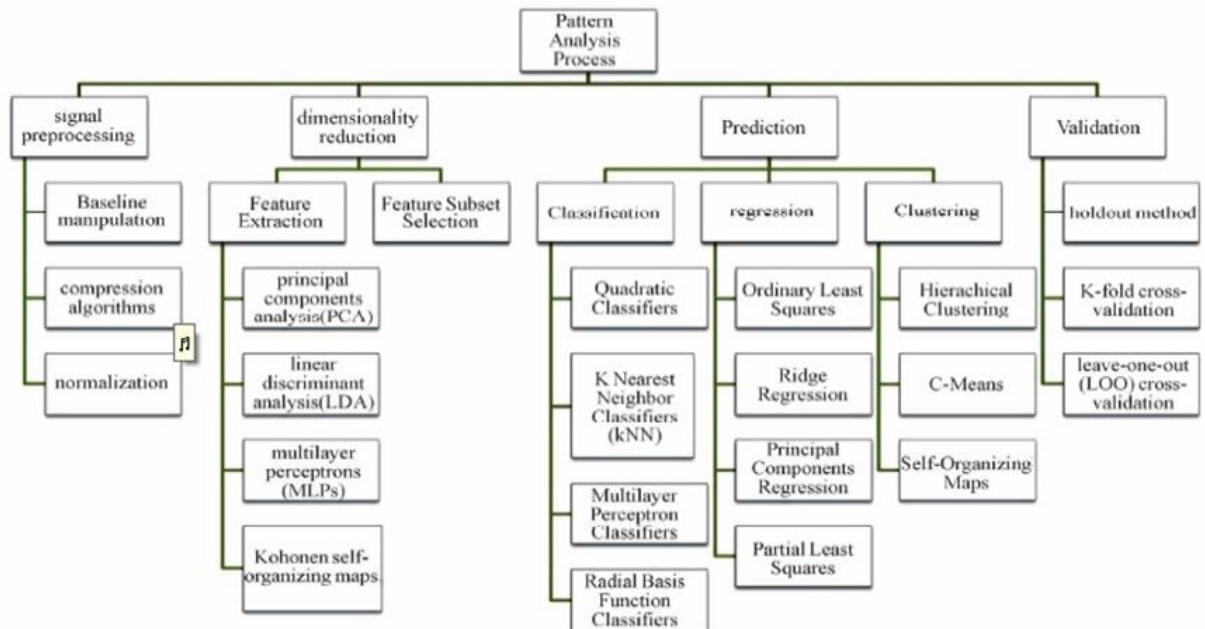


Figure 5. Data processing scheme and available techniques. (Chen, Wang and Choi, 2013)

### 3 CONCLUSIONS

Versatile sensing techniques of electronic noses continue to open new possibilities in invasive, real time, accurate and fast detection applications. These techniques have been used for various applications such as monitoring food and beverage quality, environmental monitoring, and biomedicine (Li, 2014). A new interesting application field is clinical diagnosis. Current electrical nose techniques will allow earlier detections of diseases and evaluations of patient conditions before symptoms appear. In a near future, electric noses are small, fast and accurate handheld devices.

Sensor based electronic noses have also some obstacles. Several studies show that the weaknesses are due to sensitivity to temperature, humidity and to interference with other gases. Appropriate sample pretreatment and preconcentration techniques can increase the sensitivity. By combining ordinary sensor-based technique with ISM technique the resulting hybrid device may be a possible solution.

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