UNIVERSITÀ DEGLI STUDI DELL' AQUILA

TESI DI LAUREA

"Enhancing e-Commerce applications through Internet of Things and real usage data mining"

Corso di Laurea Specialistica

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Abstract

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Acknowledgements

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Introduction

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Chapter 1

Background

1.1 The Internet of Things and the Web

During the last few years, and in an increasing manner, we have been standing at the forefront of a world where virtually everything can be connected directly to the Internet. This has resulted in an increasingly connected world where emerging technologies enable objects to be linked among themselves through the use of new devices and sensors.

This new era of the Internet has become visible in our everyday lives: from souped-up gadgets tracking our every move to environments capable of predicting our actions and emotions, the list keeps growing every day.

The Internet, consisting of things, rather than just computers, is becoming more central to society than the web as we once knew it. This does not necessarily mean that the traditional web is expected to die, but rather that its role will be reduced to that of a language used for displaying content on devices which are supposed to be more ubiquitous but are not as necessary.

The first "pioneer species" within this ecosystem of "invisible buttons" has certainly been the smartphone. Its increasing usage among the masses has made it the perfect catalyst for such a revolutionary change. One of the many uses that has helped us better understand this pioneering technology is the way that it beams information about our location and speed when we take it with us in a car resulting in a real-time traffic information accessible by everyone. In such a scenario, the actual gathering of real traffic data happens without the user ever knowing of the data transmission and without a need for interaction such as a click on a button or navigating to a particular web page.

This sort of awareness, especially as it relates to the physical world, leads to areas in space that are listening to the environment and triggering events depending on certain conditions in an entirely automatic way, like a smartphone getting into the range. There are currently applications in which the smartphone can be placed as close as two centimeters away from the top of a credit card reader to enable touch payments, or where the smartphone is detected in a large space,

such as a room, triggering an event indicating that a user has entered or exited so that the lights can bed switched on or off.

It is important to differentiate these interconnected objects from being simple on-off switches; they would not be very useful if this was the case. However, because the possible actions they can trigger can be affected by an endless list of other variables such as the time of the day, our personal preferences or the actions of others, they can quickly be scaled to reate a better program that creates more efficient interactions in our physical world.

Leveraging the use of a smartphone acting as a proximity sensor is just an artifact of the current state of technology. The same result could be accomplished with any number of sensors directly connected to the Internet so long as those sensors are capable of dealing with motion, sound, light temperature, humidity, and other variables.

Companies like Apple have been embracing the idea of invisible buttons since the beginning of this new era of sensors and devices.

While the company has been embracing the technology by foreseeing its potential from the beginning, it recently rolled out a new line of devices called iBeacon.

In a nutshell, the iBeacon allows any newer iPhone or Android phone to know its position in space with centimeter precision. Similarly to a more precise Global Positioning System (GPS) that works indoors, an iBeacon allows the developers to take advantage of the technology to define "invisible buttons" of just about any dimension.
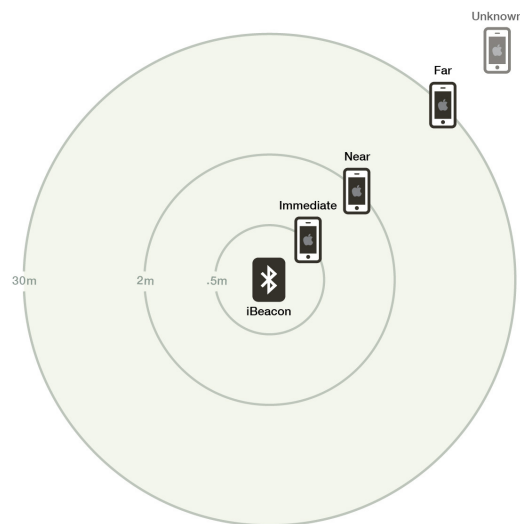

Figure 1.1: Distance categories for iBeacon

In fact, nothing is stopping this technology from being squeezed into something as small as a typical credit card, or from being embedded in any clothing or other discrete wearable de-

vices such fitness sensors, wristwatches or even temporary tattoos. The opportunities are indeed countless. Whether we wear those sensors or use them in our homes and businesses (see smart thermostats, lighting and security systems for example), they can all be prepared and trained to cooperate in sophisticated and unexpected ways once the Internet knows that we are present nearby and what our intentions might be. Imagine a smart home capable of knowing when we wake up based on the activity monitor on our wrist and begin warming up the house, brewing a pot of coffee and switching off the security system. It is evident that with such a capacity for sensing and responding to our needs, the Internet of things is slowly shaping a brand new world capable of being alive in ways that it has never been before.

Figure 1.2: A smart home ecosystem

1.2 Data and web mining

VVery often, company management requires selecting the most adequate Business Intelligence solutions that will fit its needs in order to perform crucial strategic decisions.

One of the tools used for this particular goal is a technique called data mining, which is the result of a continuous evolution that has been occuring during the last thirty years of data review. Up until the late 1970s, Business Intelligence decisions carried out their role through the use of standardized reports which contained simple summarized data and analysis.

In the early 1980s, companies began to query data in more detailed and complex ways. This made it easier to detect patterns based, for example, on an individual product or geographic area.

Currently, the advanced software available on the market for data mining is capable of perform-

ing real time pattern detection on a vast quantity of data thrown at it. This expedites a company's decision making processes and the creation of robust long-term strategies.
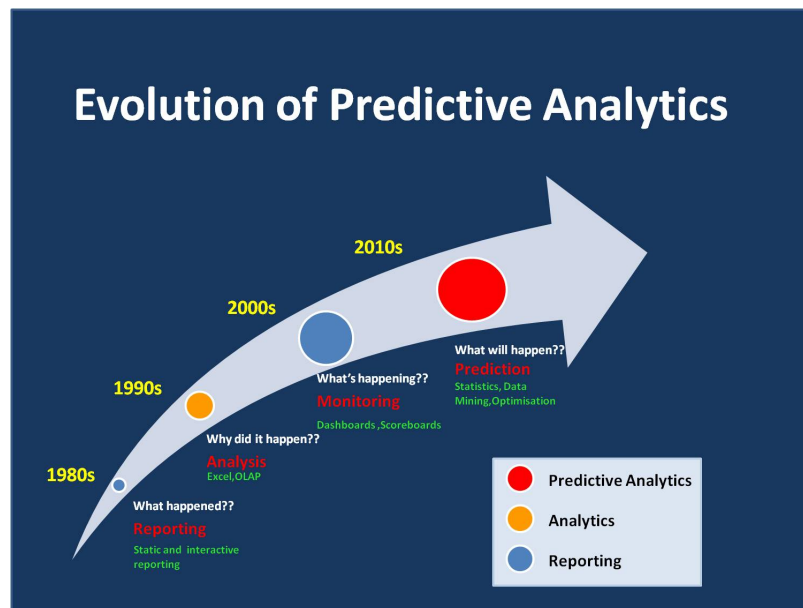

Figure 1.3: Evolution of Predictive Analysis over the last 40 years

Thorough interpretation and analysis of the available data allos the data mining process to create a better overall understanding, and helps in making better decisions.

In fact, thanks to advanced examination techniques, it is possible to find hidden information, create analytical models and data groups, and identify relationships among activities while also correcting errors.

All of this certainly leads to real advantages for a company leveraging these processes, both in terms of revenue and cost. For example, on the side of income, data mining allows companies to identify and classify the best, real and potential customers, discover additional sales opportunities, increase economic productivity and find new ways and new solutions to grow. In parallel, regarding the aspect of cost, the process could maintain clientele by identifying customer loyalty elements, reducing exposure to non-payment risks and distributing resources more efficiently.

For an organization, the reasons behind using data mining may be different. The unifying point, however, is the need to derive insight from the data that will guide the transformation, reorganization or innovation of business processes. It is evident that decisions based on accurate and reliable knowledge are always the best. Data mining, in fact, provides exactly this type of information. While Enterprise Resource Planning (ERP) systems improve operational efficiency, they do not provide the strategic drive for business growth or business change. Warehousing systems can efficiently store data, but they lack the tools to transform those figures into valuable information focused on reporting and answering mostly static questions such as areas where the

company has sold the most. On the other side, data mining tools try to present a solution to a wider range of more interesting problems, such as why sales are not taking off as expected, why customers prefer competitors or which previous marketing campaigns had the best outcomes.

Understanding the answers to these questions means taking the right measures to improve the business's performance.

Besides data visualization techniques, one of the most popular data mining processes on the market is based on the simplified transposition of the neural networks and the neural process of the human brain: when presented with models, the brain understands that some patterns are associated with other desired results. Similarly, artificial neural networks are capable, by learning about sets of historical data called learning sets, to generate patterns and validate them on other subsets of data called test sets. They operate iteratively by modifying patterns from time to time to reach an optimal solution, and they have the ability to evaluate and provide feedback on unknown data, thus making them very useful for forecasting and classifying knowledge. They are very often presented as a "black box" approach to data mining, and they turn out to be very useful when creating parametric models that are difficult to construct and when the emphasis is on forecasting rather than explaining complex patterns.
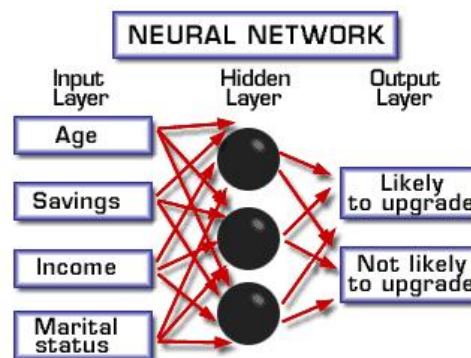
Figure 1.4: Neural networks learn to predict outputs after proper training and weighting.

After discovering what data mining means, who uses it the most, and how it is usually implemented, it is important to focus our attention on the utilization of this tool on the web and its characteristics in such an environment.

In fact, web data mining can detect behavioral models of website visitors, generate reports and implement actions based on those identified patterns. This process is possible because website visitors often unknowingly provide information about themselves and how they respond to the content presented. Monitoring what links they click, where most of their time is spent, what search terms are entered and when the visitors leave the website are just a few appetizers of the endless stream of possible data inputs.

Some visitors also provide information about their lifestyle or personal information such as

names and addresses.

Because of all of this, a thorough and adaptive analysis of this considerable amount of stored information is fundamental, and this is exactly where web data mining kicks in by helping to design the web shopper behavioral model and making valuable predictions.

One of the features that unquestionably contributes to the strength of data mining is the ability to combine emerging traffic data to the site with those related to the transactions and the profile of the buyers.

Through these combinations and by highlighting the patterns that are uncovered, it is possible to both gather complex and strategic considerations and generate predictions that may be indispensable and vital for managing a website that wants to improve its business.
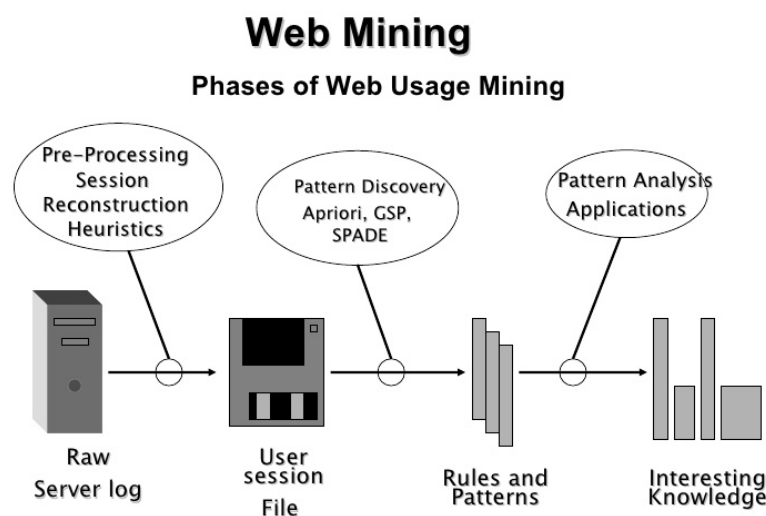
Figure 1.5: Phases of Web Usage Mining

Due to the heterogeneity nature of the source data, Web Mining is far from simply being an application of traditional data mining techniques. In fact, it can be categorized into three main types:

- **Web structure mining**: This focuses on analyzing and discovering useful knowledge from hyperlinks representing the structure of the Web. For example, these links allow us to detect relevant Web pages in a way similar to what search engines are already doing. Alternatively, it is possible to determine shared common interests among users and so on.

- **Web content mining**: The main goal of this technique is to extract valuable information or data from the content of the web pages. After doing so, it is possible to automatically classify and group this information according to topic area. While these tasks are apparently similar

to those in traditional data mining, we still can discover relevant behavioral models using product descriptions, forum posts, customer reviews and much more.

- **Web usage mining**: This technique usually refers to the identification of user access patterns from Web usage logs once the sanitization and preprocessing of the clickstream data has occurred.

Although the web mining process is similar to traditional data mining techniques, the data gets collected in an entirely different way. In traditional data mining, the data is often already available and stored in a data warehouse, whereas for the web counterpart, the effort for the data acquisition can be a cumbersome task, especially for web structure and content mining. This is due to the potentially high number of links and large quantity of pages to crawl.

1.3 Model-driven techniques

Software development techniques are continuously evolving while also trying to solve the principal problems that still affect the building and maintenance of software: time, costs and susceptability to errors.

On this topic, one of the latest research trends in software engineering is the Model Driven Engineering (MDE) technique, which was born as an extension of more specific approaches such as the Model-Driven Architecture (MDA) of the Object Management Group (OMG).[1]

MDE's primary goal is to define the methodologies and techniques to support the process related to the entire lifecycle of software development through the manipulation of models.

Before proceeding further, it is beneficial to explain the difference between MDA, Model-Driven Development (MDD), MDE and Model-Based Engineering (MBE).

The first is, by all means, an OMG standard focused on software development and using a set of defined languages utilized for a specific purpose (e.g. UML[2]). On the other hand, the focus of MDD is still on software development, but is independent of mandatory language constraints to perform its tasks. MDE, as a superset of MDD, does not only drop the software-related restrictions, but it unties itself from a particular development process, therefore expediting the definition of model driven processes to facilitate a complete software engineering process. Finally, we use MBE to refer to a softer version and a superset of MDE where models still play an important role, but are not the central artifacts of the development process. (e.g. blueprints or sketches of the system handed out to programmers directly without automatic code generation) (Figure 1.6).

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[1]The Object Management Group (OMG) is an international, open membership, not-for-profit technology standards consortium, founded in 1989. OMG standards are driven by vendors, end-users, academic institutions and government agencies.

[2]The Unified Modeling Language (UML) is a general-purpose, developmental, modeling language in the field of software engineering, that is intended to provide a standard way to visualize the design of a system.

Figure 1.6: Relationship between the different MD* acronyms.

The model is at the center of any MDE process and, to be considered as such, the modeling language that generated it needs to have well-formalized syntax and semantics. This is a fundamental condition for the automatic transformation of models. In fact, the model represents the system and constitutes an abstract and conforming formalization to a particular language. Such a language is often tailored to a certain domain and is often called Domain-Specific Language (DSL).

The advantages of using the model driven approach rely on the consideration of the generating language as a type of scheme that is also fully modelable through a formal and abstract definition known as the meta-model. In fact, the model must represent an abstraction of the concepts of the system that needs to be built, while also respecting a meta-model likewise determined by the application domain.

This reasoning can be further iterated up to the determination of a model for the representation of languages used to formalize other languages (the meta-meta model).

Because of the above, model-driven approaches are often defined by models on a stack basis as shown on Figure 1.7.

One of the most commonly used techniques in MDE is the automatic model generation based on the definition of a set of automatic transformations defined by the starting and target languages. In a nutshell, the MDE approach consists of:

- **Models Generation**, based on modeling stacks definition supporting meta-modelling methods where lower-level models comply with what is specified by higher-level models.

- **Models Manipulation** performed through transformations expected to generate destination models which conform to destination meta-models when provided with source models that conform to source meta-models.

In summary, MDE techniques allow, on the one hand, for the management of the complexity of a system by ensuring increased productivity, and for quality improvements by promoting a higher level of abstraction and reuse, on the other. This result is achieved through a process of engineering, both for the languages and the transformations involved: they are, in fact, the basis of a system's development process because they represent the transition from higher-level models
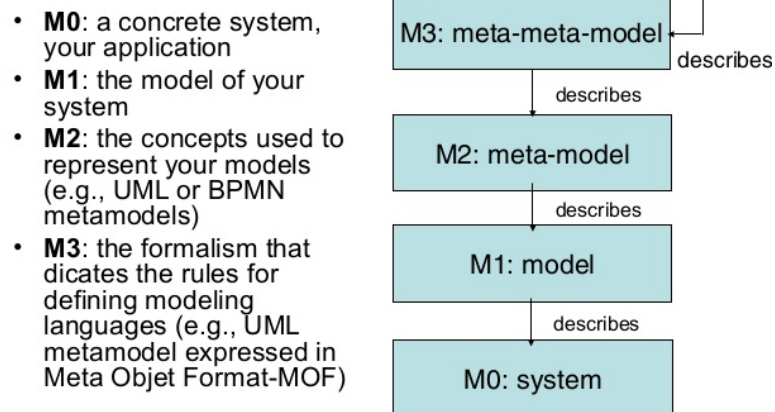
Figure 1.7: Models stack

into lower-level ones until they can be made executable using either automatic code generation or model interpretation.

Chapter 2

State of the art

2.1 Big Data and Predictive Analysis

The concept of Big Data relates directly to the Internet of Things: IoT devices are indeed capable of collecting terabytes of data in a short amount of time, therefore being proficient a interpreting and analyzing such information is quite critical.

It's important to notice not only IoT devices are players capable of generating profiling data at such an incredibly high rate; the modern Web represents another essential data source in this paradigm: social networks, for example, are capable of producing an endless stream of data describing user preferences and behaviors at any time.

This vast volume of data available to analyzers is behind the term Big Data which can be taught as a massive dataset, growing at a very high velocity in numerous formats from a variety of different origins.

To obtain business value from this amount of information, companies necessitate algorithms and solutions fitted to efficiently process, validate and give credibility to it, solutions beyond traditional systems currently used for managing and storing information, with high power and high calculation inclination that are efficient for sorting data in a structured and meaningful manner to detect relationships and patterns.

This new approach to data management differs from what companies used to do in the past when priorities were bound to an IT level governance only and they were solely accessed by a restricted set of users.

It also becomes vital for a company to quickly and correctly identify new sources of big data when they become available on the market incorporating them into the data management platform following a constant continuous improvement logic.

It's quite hard to estimate in advance the added value brought by the Big Data analysis to the various application disciplines in which they can be applied, but they certainly warrant an improvement of the quality of the forecasts offering useful tools to take more prudent decisions

supported by more robust empiric evidence.

In fact, Big Data analysis constitutes a fantastic instrument in the field of the decision-making throughout the whole organization pipeline minimizing the risks and reducing the errors caused by possibly wrong human intuitions at any level. For example, the Marketing department could potentially leverage big data for increasing marketing intelligence predicting customer interests while Logistics can utilize Big Data to better forecast product stock refurbishment or Operations can use it to optimize production requests.

Figure 2.1: The five fundamental Vs of big data

In a nutshell, the potential applications mentioned above represent the core of the predictive analysis notion: the practice of extracting information from Big Data with the goal of determining patterns and predicting future outcomes and possible trends.

It's important to notice that this kind of analysis does not offer a precise statement of what will happen in the future but rather they forecast what might occur with an acceptable level of reliability including what-if scenarios and risk assessment.

Focusing on the Marketing intelligence example mentioned above the benefits of using Predictive Analysis are immediate to understand. Indeed, it is one of the possible applications digital companies are embracing with the fastest rate nowadays, mostly because it allows them to offer better and more constructive experiences to the customers on every possible point of contact between the business itself and the clients with the goal of increasing customer loyalty and, naturally, incomes.

In detail, this process takes place using sophisticated algorithms and mathematical models on top of the big datasets of customers activity accessible from Big Data sources; eventually, this

data gets sanitized, structured and filtered and finally grouped in a meaningful way.

The behaviors and patterns of interaction detected by this process can indicate, for example, a more appealing product offer with a major chance of conversion for a particular customer profile segment.

As mentioned above different typologies and techniques are used to perform this type of analysis for behavioral prediction, these are the most important ones :

- **Clustering or Unsupervised learning**: This methodology groups similar individuals and identifies with high precision the enterprise's customer base. The algorithm processes hundred of attributes until it identifies the discriminating ones for a more efficient segmentation: the underlying idea is that several statistically significant groups behave in the same way.

  The clusters obtained with this process are similar to groups determined through a priori segmentation; the fundamental difference between the two methodologies is that, while segmentation involves assigning customers to previously identified groups, clustering allows to distinguish the natural disposition of individuals in the different groups based solely on data and not preventive attributes definition.

  Clusters can be of different types depending mostly on the criteria by which customers are grouped : product-based clusters, for example, gather all customers who tend to buy products or combinations of several products in the same category, brand-based clusters, on the other hand, focus on customers who prefer certain brands instead of others while behavior-based clusters combine consumers with similar buying behaviors, helping the marketing manager to identify the most appropriate way to address each of them.

- **Propensity models or Supervised learning**: This technique is based on probabilistic models using advanced machine learning techniques such as neural networks, logistic regression, random forest, and regression trees. The main purpose of these procedures is to predict future customer behavior based on past examples. Over time, these algorithms become more efficient, hardening forecasts with more data.

- **Reinforcement learning and Collaborative filtering**: This highly used technique in making predictions has major applications, one of the most famous one being the recommendation suggestion which offers tips on which products to buy. The recommendations are targeted and tailor-made for the client and they are obtained taking into consideration the entire relationship between customer and brand. Respectively they can upsell for higher value products, cross-sells to same category items or dynamically link other products based on the bought-together association.

2.2 RFID, NFC, Beacons and Sensors

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Chapter 3

Overview of the combined approach

3.1   Monitoring and acquiring data

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3.2 Representing and modeling

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3.3 Mapping to code

Chapter 4

Implementation

4.1   Monitoring and acquiring data

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4.2   Representing and modeling

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4.3   Mapping to code

Chapter 5

Case Study

5.1 web site magento + iot devices + modifiche che si volgiono fare per migliorare marketing/fidelizzazione etc

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5.2 applicazione dell approccio sul caso di studio

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Chapter 6

Related work

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Conclusions

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