Brainstorm on artificial intelligence applications and evaluation of their commercial impact

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ABSTRACT

A countless number of artificial intelligence applications exist in a wide range of fields. The artificial intelligence (AI) technology is becoming mature, free powerful libraries enable programmers to generate new apps using a few lines of code. The study identifies the applications that are the most interesting for a developer as far as profit is concerned. Some AI applications related to trading, industry, sales, logistics, games, and personal services have been considered. To select the most promising AI applications, multi criteria methods have been adopted. This brainstorm may be useful to inspire new born start-ups, willing to create viral apps/products. The paper wishes to be informative and light, for further information, a rich selection of publications and books is provided.

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1. INTRODUCTION

The term artificial intelligence (AI) was coined by John McCarthy in the mid-1950s, with the following meaning the science and engineering of making intelligent machines. John worked on some of the world's most innovative technologies such as: programming languages, the Internet, the web, and robots. John invented the first programming language for symbolic computation lisp. AI may be considered, in general, as a black box able to solve problems; it produces specific results from an input. The Antikythera Mechanism is probably the first computer: it is a 2000-year-old mechanism that looks like a Swiss watch with gears, it is supposed to be a greek astrological mechanic calendar. It took several years of technology development before it was possible to use these architectures successfully. In an early period between the 1960s and 1970s, knowledge-based systems (KBS) and artificial neural network (ANN) systems were developed as AI systems. The former proposes solutions by processing predefined rules that have been set by humans, based on their experience; examples of knowledge-based systems include expert systems, which are so called because of their reliance on human expertise. The latter are black boxes that are trained with a large amount of input/output data. The limited availability of data made AI applications scarce in this period. Only since the 1980s did the use of AI start to grow: the increasing availability of data enabled the development of machine learning: the computer accesses large amounts of data and extracts knowledge from it to solve specific problems. Automatic machine learning is a subcategory of AI that differs significantly from previous techniques that saw humans as teachers of the computer. Today this technology is mature, at least for the following reasons: data storage systems are relatively inexpensive, millions of sensors are recording daily creating “big data” to analyse, in the World about 3.8 billion of people use smartphones (high end computers), almost all devices are interconnected (internet of things), computational power is fast (NVIDIA A100 Tensor Core GPU). Any calculator or computer is capable of AI. Python is one of the best solutions to create ambitious big size AI projects. There is a rich online python community ready to support the developers. Several works introduce the basic concepts of AI applications [1], [2].

The potential value of AI in different sectors has been analysed and compared by a McKinsey study [3]. The study indicates that AI could potentially create from $3.5 trillion to $5.8 trillion in annual value in the global economy. To achieve the benefits, however, several limitations and barriers to the application of AI must be overcome. For instance, a large volume and variety of often labelled training data are needed. The value of AI is not in the models themselves, but in the ability of organisations to exploit them. Business leaders will need to prioritise and make careful choices about how, when, and where to implement them. The study by McKinsey identifies the sectors where AI could have the greatest impact on revenues. The work presented in the present article has a different point of view. The research wants to be of support for those who develop AI applications to choose the market and the applications where there is the highest potential. The paper is structured: in section 2 the theoretical basis of multi-criteria analysis is presented. In section 3, the process for the identification of the project alternatives is described. Section 4 refers to the definition of the judgement criteria. Section 5 presents the evaluation matrix and section 6 presents the results of the adopted multi-criteria analysis. The results from the proposed methodology are compared with the results from the McKinsey study. Conclusions follows.

2. THE THEORETICAL BASIS

The aim of the research is to look for contexts in which AI application developers can achieve the greatest commercial impact. AI applications are born to solve different needs, from different fields: it is not trivial to compare and select the most promising ideas. When make it necessary to use criteria that are to a large extent non-monetizable, as it is in the proposed research, it is necessary to resort to the set of procedures that go by the name of multi-criteria analysis. The stages of the multi-criteria analysis can be summarised as:

i) Identification of the project alternatives.

ii) Definition of the judgement criteria: they represent the tool by which the achievement of a final objective is measured; identification of the weights of the judgement criteria in relation to the final objective; the goal is to maximise the profitability of application developers in the AI field.

iii) Definition of the evaluation matrix whose elements represent the scores by which the effects of the alternatives are measured against each judgment criterion.

iv) Comparison of alternatives and final choice. Precisely, based on the way in which the alternatives are compared to assess their effect in relation to the final objective, the methods of multi-criteria analysis are divided into two fundamental classes:

– Compensatory: they allow compensation between the effects of a project in relation to different criteria. To the first group belong the multi attribute utility theory (MAUT) and the analytic hierarchy process (AHP). The latter method was applied in the research.

– Non-compensative: they do not allow compensation between the effects of an alternative on different criteria of judgement. The methods of concordance analysis belong to this group and among them there are the methods of the electre family. The electre I method was applied in the research.

The AHP method structures the decision-making process at several levels. In the present study, as shown in Figure 1, three levels have been considered: at the highest level we have the final objective, i.e., maximising the profit of developers of artificial intelligence applications, at the intermediate level the judgment criteria and at the lowest level the design alternatives.

The method aims to establish a weight for each alternative in relation to the final objective, and then a ranking of the alternatives. The weight (p_{ko}) of the alternative *k* in relation to the final objective *o* is given by the linear combination of the weights (e_{ki}) of the alternative *k* with respect to the judgment criteria *i* (for all the judgment criteria *i=1..n*) whose coefficients are, in turn, the weights (γ_{io}) of the judgment criteria *i* with respect to the final objective *o*.

$$p_{ko} = \sum_{i=1}^{n} e_{ki}\gamma_{io}$$

In this way the column vector of weights of the alternatives with respect to the final objective [p_{A0}, p_{BO},..,p_{KO}] is obtained as the product of the evaluation matrix [e_{A1}, e_{A2},..,e_{An}; e_{B1}, e_{B2},..,e_{Bn}; ...; e_{K1}, e_{K2},..,e_{Kn}] and the column vector of weights of the judgement criteria with respect to the final objective [γ_{10}, γ_{2o},.., γ_{no}].

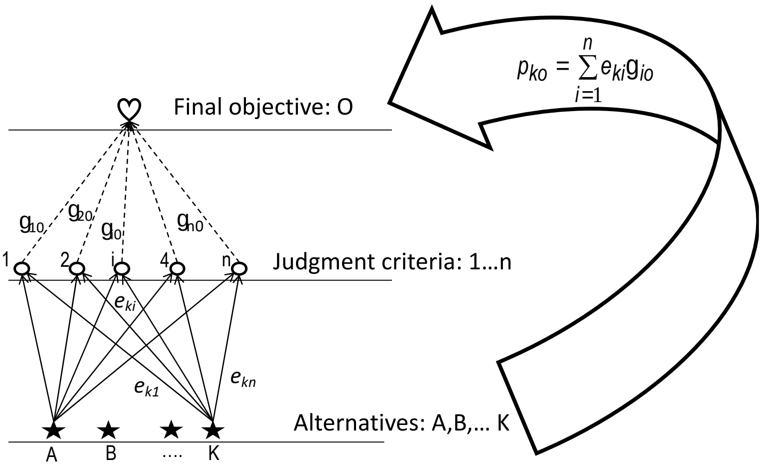

Figure 1. Outline of the AHP methodology

The key aspect of concordance analysis is that alternatives are compared two by two. The comparison is based on the evaluation matrix-the elements of which have been normalised and made directional- and the weights of the judgment criteria in relation to the final objective. This pairwise comparison then allows the calculation of concordance and discordance indices. The first is a measure of the dominance of alternative *x* over alternative *y*, the second is an expression of the superiority of *y* over *x*. The two indices are calculated according to:

$$c_{xy} = \frac{\sum_{n \in \Psi_{xy}} \gamma_n}{\sum_n \gamma_n}; \quad d_{xy} = \frac{\max_{n \in \Phi_{xy}} (\gamma_n |e_{xn} - e_{yn}|)}{\max_n (\gamma_n |e_{xn} - e_{yn}|)}$$

where Ψ_{xy} e Φ_{xy} are the sets defined as:

$$\Psi_{xy} = \{ k \mid e_{xk} \geq e_{yk} \}$$

$$\Phi_{xy} = \{ k \mid e_{xk} < e_{yk} \}$$

and where e_{xy} is the generic, normalized, directional element of the evaluation matrix. It can be observed that the degree of concordance for each pair of alternative projects is a ratio between weights only, while the degree of discordance also considers the differences between the scores of the two compared pairs. From an interpretative point of view, it can be said that the degree of concordance expresses a weighted proportion of the criteria favourable to *x* with respect to *y*. The degree of discordance, on the other hand, expresses a proportion of the better propensity to implement *y* rather than to implement *x*. However, several other interpretations can be given. The electre I method aims at skimming the alternatives, trying to identify a subset of alternatives that are considered unacceptable because they are “inferior” to the others as show in Figure 2. The method does not, however, aim to rank the acceptable alternatives.

In order to divide the set B of alternatives into the two complementary subsets (A and U in Figure 2), the analyst chooses two thresholds: η and μ; both values must be between 0 and 1; η closer to zero, μ closer to 1. The indexes of concordance and discordance of the alternatives are compared with these threshold values: if, given a pair (*x*,*y*) of alternatives, it turns out at the same time

$$(*) \begin{cases} c_{xy} \geq \eta \\ d_{xy} \leq \mu \end{cases}$$

there are no elements to assert that *x* is worse than *y*.

$$(**)\begin{cases} c_{yx} \geq \eta \\ d_{yx} \leq \mu \end{cases}$$

If, on the contrary, both (*) are satisfied and at least one of the (**) is not verified, we can assert that project x is superior to project y. By examining in this way all the pairs of alternatives, it is possible to partition the set B into the two subsets: A is formed by the alternatives for which it is not possible to identify the superiority of one alternative over another of the same subset. The complementary subset U is formed by the alternatives for which at least one higher-ranking alternative belonging to A, has been identified. The electre I method thus makes it possible to establish that the alternatives in A are better than the alternatives in U, but it does not make it possible to compare the alternatives in A with each other. If the set A consists of only one alternative, this is the best alternative. If, on the other hand, A contains several alternatives, it is possible to reduce the number of alternatives in A by modifying the weights attributed to the judgement criteria and/or by bringing the values of the thresholds η and μ closer together.

In the proposed research, the comparison of alternatives is carried out using the AHP methodology. Subsequently, the electre I method has been also implemented. The aim is to check whether it is possible to make only one alternative remain in the set A by varying the values of the η and μ thresholds. If it is possible, then it can be stated that, all the other alternatives can be considered unacceptable because they are "inferior" to the one in the A set. The claim would be reliable as it has been shown that the electre method has lower sensitivity than the AHP method to changes in the weights [4]. The following paragraphs refer to the 4 stages of the multi-criteria analysis and describe how each phase was approached in the study.

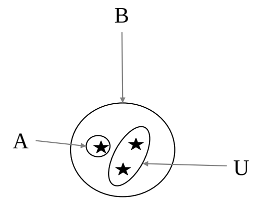

Figure 2. The set B of alternatives is divided into two subsets: A and the complementary set U=B/A

3. METHOD: THE IDENTIFICATION OF THE PROJECT ALTERNATIVES

It is somehow complex to create a method able to identify and select the best AI project alternative; while the brainstorming phase needs to be "free" to unlock the creativity, the evaluation phase avails of a "rigid" standardized judgment criteria, necessary to provide an objective evaluation. The evaluation is performed on a few general key parameters that can be applied on each idea proposed. For a better understanding, a flowchart of the methodology adopted is provided as shown in Figure 3.

The process flow, used to define and select the AI applications, is subdivided in four main steps. The first phase is creative, free, open, and unconstrained; a pool of multidisciplinary researchers, thanks to different sessions of brainstorming, looks for potential customer needs. The customer satisfaction is the main goal. During this phase, any idea can be proposed and analysed. Then, one or more AI products are proposed to solve each customer need. This process is not always straight forward; some general customer needs, like "people like to have more spare time", deserve more elaboration time to be fulfilled. The same need may be satisfied using a cluster of AI integrated applications. The brainstorming phase ends with a preliminary feasibility study; in this early stage, a first attempt is made to identify the potential of each application. This early feasibility study acts as a filter; only the applications that show a limited potential are rejected.

It is now time to give a more refined shape to the ideas proposed. The second step of the process flow consists in classifying and cluster the customers by field of interest. The methodology allows to enucleate 6 fields of interest (in blue): trading, industry, sales, logistics, games, personal services. Each field of interest identifies a specific customer; the identification and the deep knowledge of each customer is crucial, to better serve him. Then, one or more specific applications are defined, tailored on the customer wishes: the active game application is born out of a desire to satisfy children's need to play exciting games, while the virtual volunteer application is born out of a desire to satisfy elder people wish to share emotions. Overall, 22 AI applications (in the green boxes of Figure 3) are proposed. AI may be applied to almost any field; the list of proposed applications is described in Table 1 (see in appendix) and does not want to be exhaustive.

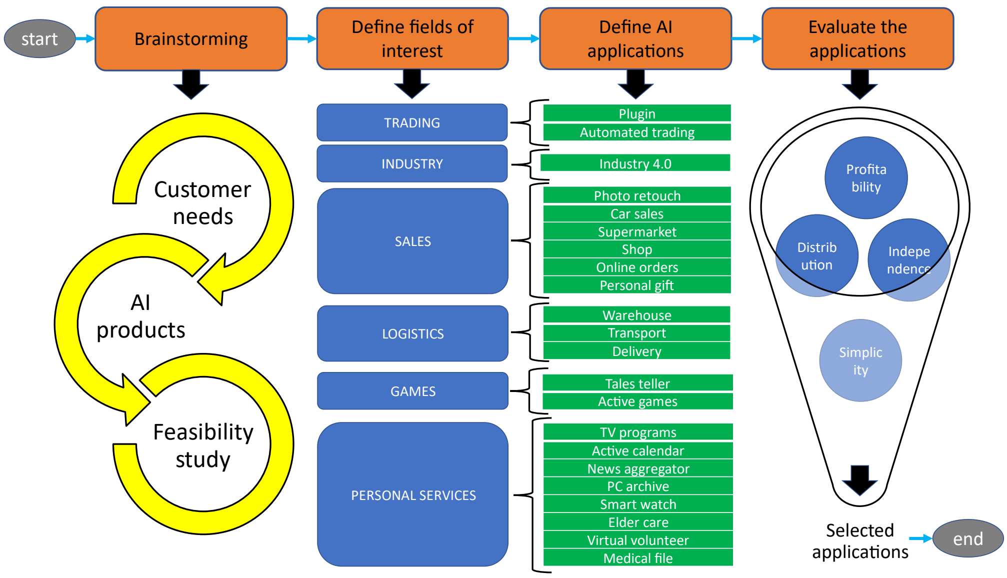

Figure 3. Shows the flowchart of the AI-based models and experimental methods applied

4. METHOD: THE DEFINITION OF THE JUDGEMENT CRITERIA

A multidisciplinary panel of experts, from the trading, industry, sales, logistics, games, personal services macro-areas, has been created. The experts have selected 4 criteria of judgement: Distribution, Profitability, Independence and Simplicity. Distribution refers to the number of clients that potentially may use the service and is measured as potential number of clients (N clients). Profitability is assessed as the potential earning per unit of product installed/sold (€/unit). Independence (from hardware) is the ability of the code to run, for example on mobile phones, without the need of dedicated hardware. Simplicity (of development) is inversely proportional to the time necessary to develop and maintain the code. These judgement criteria are represented as 4 blue spheres in the funnel in the fourth phase in Figure 3. As it concerns the identification of the weights (γ_{io}) of the judgment criteria with respect to the final objective, it was assumed that all criteria have an impact to the same extent on maximising the profit of developers of AI applications. This assumption is affected by a degree of discretion. To reduce this discretion, it is planned to apply, in the future, the technique of indirect quantitative determination, using comparison matrices.

5. METHOD: THE DEFINITION OF THE EVALUATION MATRIX

The experts have filled in a 1st evaluation matrix, which has as many rows as are the alternative projects and as many columns as are the judgement criteria. Each value of the first matrix represents a measure of how well the project (corresponding to the row) meets the criterion (corresponding to the column). Each value of the 1st matrix is a score ranging from 1 to 5 (stars). The value is determined using the Delphi method: the experts have been iteratively interviewed, until they converge on a single value for each assessment.

Each value is an ordinal measure, meaning that indicates the position of the project in the ranking list. The assessed values have been elaborated, to have a 2nd evaluation matrix containing cardinal, normalised and directional quantities. Given x_{ij} as the “raw” score that in the 1st evaluation matrix expresses the correspondence of alternative *i* to criterion *j*, the relative normalised value e_{ij} was obtained with:

$$e_{ij} = \frac{x_{ij}}{\max_j(x_{ij})}$$

The 2nd evaluation matrix is reported in Table 2. It has as many rows as there are the alternatives (AI projects) and as many columns as there are the judgement criteria (four). The generic element represents the normalised and directional weight of the alternative corresponding to the row, in relation to the judgement criteria corresponding to the column. In Figure 4 each alternative is represented by a column. The total height of the column represents the total weight assigned to the alternative and results from the sum of the weights as shown in Table 2 of the alternative corresponding to the four judgement criteria (the contributions of the weights to the four judgement criteria are represented with different shades of colour).

Table 2. The 2nd evaluation matrix of the proposed AI applications

AI Project	Distribution (N Clients)	Profitability (€/unit)	Independence (from hardware)	Simplicity (of development)
Plugin	0.4	1	0.4	0.4
Automated trading	0.2	0.8	0.6	0.2
Industry 4.0	0.4	0.8	0.4	0.4
Photo retouch	1	0.4	0.6	0.8
Car sales	1	0.6	0.8	0.8
Supermarket	1	0.8	0.6	0.6
Shop	1	0.8	0.8	0.6
Online orders	1	0.8	0.6	0.8
Personal gift	1	0.8	0.8	0.8
Warehouse	0.4	0.8	0.6	0.8
Transport	0.4	0.6	0.4	0.6
Delivery	0.6	0.6	0.8	0.8
Tales teller	0.8	0.4	0.6	0.6
Active games	0.8	0.	0.2	0.6
TV programs	1	0.4	0.8	0.6
Active calendar	0.6	0.4	0.8	0.6
News aggregator	0.6	0.4	0.4	0.2
PC archive	0.8	0.6	0.6	0.6
Smart watch	0.6	0.4	0.2	0.6
Elder care	0.8	0.6	0.8	0.8
Virtual volunteer	0.4	0.6	0.4	0.2
Medical file	0.8	0.8	0.6	0.2

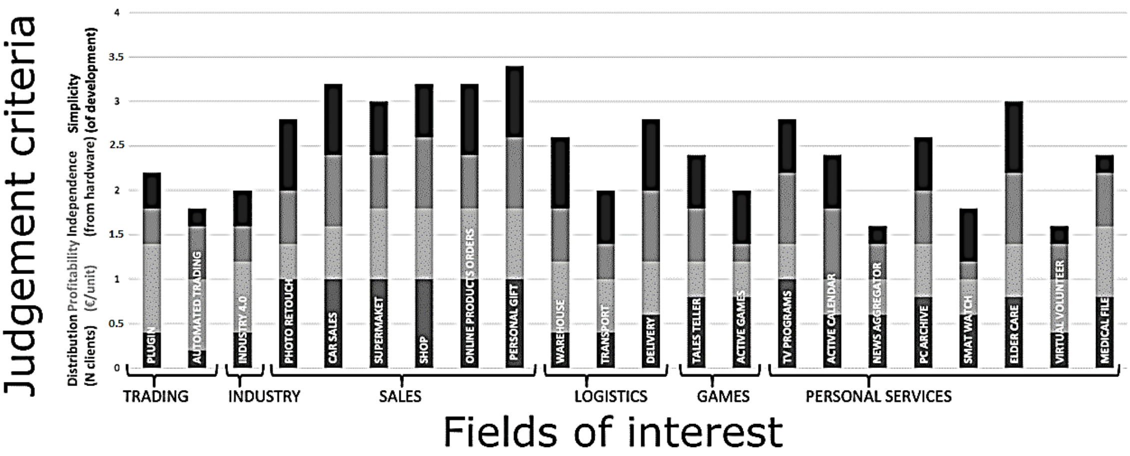

Figure 4. A comparison, based on the AHP method, among the proposed AI applications

6. THE COMPARISON OF ALTERNATIVES: RESULTS AND DISCUSSION

The brainstorming feasibility study, driven by the feelings/experience of the researchers, allowed to preliminary filter the ideas. The comparison of the applications, based on the 4 judgement criteria, allows now to select the most promising AI applications. This step is the last one in Figure 3 and it is represented as a funnel. The comparison of the applications has been performed first, by applying the AHP method secondly, by applying the electre I method for comparing the best projects resulting from the AHP analysis.

According to the AHP method, a final score is assessed for each project through the weighted summation method. The outputs of the AHP method show that the most promising ideas are: ‘personal gift’, ‘car sale’, ‘shop’, ‘online product orders’ (belonging to the sales macro-area) and ‘elderly care’. Therefore, the sales macro-area is the most profitable for AI application developers.

Interestingly, according to Kinsey’s research [3], marketing and sales are one of the two macro areas where the potential impact of AI is greatest. The other macro-area identified by the McKinsey researchers is the area of supply-chain management and production. However, this macro-area does not seem to be as profitable for AI developers as it is for AI users. The reason might be that (at least for Industry 4.0, considered in our study), the customisation of specific AI applications, required by different factories, and the difficult integration of sensors into complex systems, which provide the required big data, make the development of AI applications in this area time-consuming and not so profitable. Each factory is particular and relies on specific hardware, which is why the process of developing industrial applications offers only limited scalability.

The data in the 2nd evaluation matrix can also be used to make some general considerations as shown in Figure 5. The highest scores were awarded in the criterion distribution: we live in a global connected world; the distribution of the AI applications is relatively easy. Profitability received lower scores: profitability in fact, depends heavily on the marketing strategy adopted; people often receive "almost free" professional digital services; hence profitability is not always straightforward. A persuasive marketing plan needs to be elaborated, to accomplish the "AI product sale". Independence received slightly lower scores than profitability because not all the proposed AI applications can run directly on mobile applications; independence from hardware cannot always be guaranteed. The lowest scores were awarded in the simplicity criterion, because the time required for software development generally risks lowering the margins.

The electre I method has been applied to compare the projects 'personal gift', 'car sale', 'shop', and 'online product orders'. These projects are in the sales macro-area that resulted the more promising one from the AHP analysis. Having fixed $\eta=0,5$ and $\mu=0,55$ as threshold values, the project 'personal gift' resulted the only one in the A set, where the set A is made up of the alternatives in respect of which no other project has been found to be superior as shown in Figure 2. All the other alternatives belong to the U set in Figure 2 and can therefore be considered "inferior" to the 'personal gift' project.

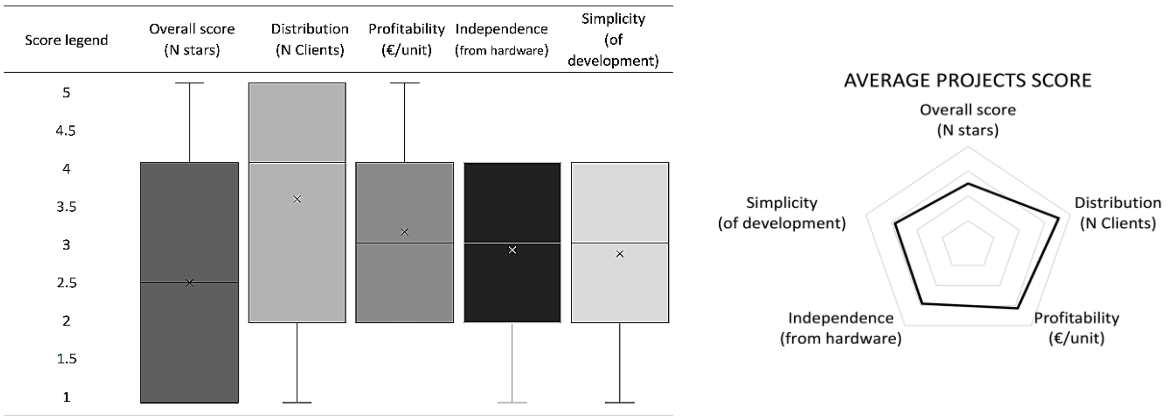

Figure 5. Shows the statistics distribution of the AI projects scores

7. CONCLUSION

The ability of encapsulating bits of human intelligence inside a self-standing "learning and thinking device" opens unlimited possibilities. Out of clichés and in the name of concreteness: data have value to the extent that they allow to improve the productivity of a company, when they allow it to become more efficient, to create and develop better products, to increase the satisfaction of own customers or even to enter new markets or develop new business models. AI allows you to increase these potentials and allows you to accelerate all the knowledge processes that lead to the achievement of these objectives and which are the basis of the self learning enterprise, a definition by which we mean those companies and organizations that decide to grow own knowledge potential and put it to value, available to the business. New software and hardware technology developments daily widen AI capabilities. A few examples of new AI applications have been described for the following fields: trading, industry, sales, logistics, games and personal services. The ideas proposed are only briefly described, with the aim of soliciting the imagination of the reader. Ideally, for any new ideas proposed, a start-up may be created, able to financially exploit the specific "automated service". Then, a methodology to compare the ideas has been introduced, based on four key parameters: distribution, profitability, independence and development. The best applications reach a wide public, have a high profitability, are independent from hardware and need limited coding time. An important goal of this brainstorm is to arouse the reader's curiosity, leading him/her to find and solve existing problems, thanks to the AI powerful tools today available. On a daily basis, new start-ups create AI apps that run on our smartphones Worldwide. The proposed brainstorm, on commercial AI applications, may help today's CEO, selecting the next commercial digital products.

APPENDIX

Table 1. The proposed applications: project alternatives

Field of interest	Project alternatives	Project description
Trading forecasts	*Plugin*	The task is to give trading advice. For example, Metatrader® supports users giving real time forecasts and their probability to happen [5], [6].
	Automated trading	AI platforms that are designed to work without human supervision [7]. For example, high frequency trading sends orders to the market with a milliseconds or microseconds frequency. Ethical problems issue: the AI, with the aim of chasing pure profit, may choose for us toxic financial strategies
Industry	*Industry 4.0*	An Industry 4.0 production environment allows a strong customization of products under the condition of high flexibility (mass) production [8]. The sensors used for the production create a huge amount of data that needs to be evaluated. For example, Braincube® (braincube.com) is a commercial software that helps to select and tune the crucial production parameters. The machine learning creates a sort of mathematical model of the process, and sets the optimised production parameters, for the next batch of production. A predictive digital twin online process simulation is used to foresee and solve problems before they happen [9], [10].
Sales	*Photo retouch*	Modern fast communication is often spread using images, while the text is almost disappearing. Each photographer needs to give a special "appeal" to his photos, to beat the worldwide competition. AI may be used to create a self-adaptive filter that first examines each photo, and then dynamically applies custom parameters [11].
	Car sales	AI may be used to find an objective value for the cars on sale [12]. This service first asks all the characteristics of the car, and then provides a certified reference price for the sale in a specific country. This certification helps to gain confidence, both for the seller and for the buyer.
	Supermarket	AI may help to drastically reduce food waste. AI can dynamically change the price according to deadlines/offers [13]. It can also predict all the goods that will never be sold in time and organise a charity donation to the poor people. Moreover, AI can help to optimise supplies, to eliminate unsold and expired products.
	Shop	AI can also push the customer experience at the next level [14]. AI will analyse the purchases of each customer. Valuable customers will receive better discounts, oriented to the goods they buy more often. A mobile phone app may be the personal interface to build the loyalty between AI and the customer. AI may also help to easily find the goods inside a shop; two approaches can be followed: change of merchandise location or change the shop layout. AI may simulate and optimise the movements inside the shop.
	Online orders	A commercial AI plugin may help to select products, according to customers' tastes; eBay browser will show for “sunglasses”, first the model of sunglasses you like most.
	Personal gift	The AI advisor needs to know the gender, age, and personal taste of the guest of honour. The advisor then, according to the given budget, will propose a shortlist of gifts [15].
logistics	*Warehouse*	The task could be managing the space to optimise product picking [16]. AI automatic filling algorithm may save space inside a moulds warehouse [17].
	Transport	AI can be integrated with traffic detection systems, for forecasting traffic volumes and warning conditions, that anticipate road accidents. AI can improve collective transport. Autonomous vehicles can be connected, with the aim of increasing the accessibility of rural areas, reducing the number of accidents. AI can simplify the displacements of those who cannot use collective transport, and who do not have a driving licence. The travel can be planned from peak hours to off peak hours, where possible [18].
	Delivery	The context could be proximity e-commerce where the target is to satisfy customer preferences, allowing for instance last minute changes, in order lists and/or delivery addresses, minimising the travelled distance [19], [20]. The target is to improve the complex multi commodity pick-up and delivery travelling salesman problem, reducing the execution time [21].
Games	*Tale teller*	The AI storyteller tells goodnight stores to the children [22]. Each story is different and is based on random or custom subjects.
	Active games	"Active games" are classic video games with real life outcomes [23]. The concept of "active games" can be applied both for children and for elder people. Game activities include gymnastics, memory games and phone calls to friends. AI teaches to the children the balanced entertainment mix among digital, social, and physical life.
Personal services	*TV programs*	The dilemma is: "Is there anything interesting to watch tonight?". Instead of doing an endless zapping, AI may suggest specific programs, tied for the audience in front of the television [24].
	Active calendar	"What to do today?". The digital AI calendar best fits the daily activities to do, according to weather conditions, family needs, and working needs. The calendar is also able to find and manage conflicting conditions.
	News aggregator	Often the news, found on the web, seems to be polarised. It is difficult, for the user, to develop his own point of view. Fake news is also not easy to discover [25]. The news aggregator is a “research bot”, like Google, that shows and weighs together different points of view on the same topic.
	PC active	Sometimes people have many documents placed unsorted on their PC desktop; there is the risk of losing them. The PC archive service may automatically archive and find documents. Also, logical maps may be created [26].
	Smart watch	An elder person, that lives alone inside a house, creates safety concerns. Smart watches already can keep track of biometrics data such as: blood pressure, oxygenation and physical activity done [27]. This data may be real time monitored and actively used by AI algorithms to save the elder people life [28].
	Elder care	An elder care AI platform, like Alexa [29], may offer a rich list of customised services.
	Virtual volunteer	AI platforms allow volunteers to speak remotely, using a video conference app, such as Skype. Elder people may use their television as a video interface. This solution helps to optimise the transport time. A further step is to virtualize the volunteer: when the volunteer is not available, a virtual volunteer may replace him [26].
	Medical file	The classification of diseases is a classic task [30], [31]: for example, the LYNA algorithm, analysing medical images, can help to find tissue problems. Surgical training simulation is another rich medical field. AI can correlate the data of the patient with the data of millions of patients having a similar disease, offering a valuable clinical decision support system.

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