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Validation of Intelligent Systems: A Critical Study and a Tool, Corus

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Abstract: The school/university orientation interests a broad and often badly informed public. Technically, it is an important multicriterion decision problem, which supposes the combination of much academic professional and/or lawful knowledge, which in turn justifies software resorting to the techniques of Artificial Intelligence. CORUS is an expert system of the "Conseil et ORientation Universitaire et Scolaire", based on a Knowledge Representation Language (KRL) with rules and objects, called/known as Ibn Rochd. CORUS was developed thanks to DéGSE, a workshop of cognitive engineering which supports this LRC. CORUS works out many acceptable solutions for the case considered and retains the most satisfactory among them. Several versions of CORUS have extended its services gradually.

Key words: Knowledge engineering, multicriterion decision, knowledge-based systems

INTRODUCTION

The cognitive modelling of this software is based on the analysis of the actual activity of a career advisor, according to methods inspired from Cognitive Psychology. A career advisor articulates his activity on the analysis of the pre-ferences of consulting people, high-school pupils or students, engineers or staff, the obstacles of the formations and the requirements of the professions and trades. The context knowledge makes it possible to reach solutions. Evaluating the solutions reached supposes a multi-criteria approach. So, the school/university orien-tation is a multicriterion decision problem resting on im-perfect knowledge, difficult to objectivize. A computerized decision-making system for student orientation will be based on a system containing knowledge, which justifies the resorting to artificial intelligence techniques before tackling the question of the acquisition of knowledge and machine learning. The repertory grids are chosen as a of method of acquisition. Hence we are interested in the coding of the system carried out in our KRL Ibn Rochd, using DéGSE (its development workbench). Several versions of the system have been carried out progressively (by extending the field, services and interactivity). CORUS rests on resolver handling the numerous decision criteria. In a relatively classic way, the resolver (inference engine) tries not to explore the set of the solutions space.

Student orientation and artificial intelligence: The conception and development of a tool of assistance to student orientation imply two main activities:

- to extract, formalize and file the situations of the orientation system in order to constitute a library of cases covering the problem wholly;
- to exploit knowledge filed in order to release a know-how in student orientation likely to help the experts to formalize the analysis.

In order to automate cleverly (rather than completely) the activities of student orientation - not yet theorized - we must consider:

- requirements of the consultants (student or high-s chool pupil, parents, person in charge, the hand i c apped people, staff, the administrator of this b a se…),
- descriptions of the formations (pre-academic, academic and post-academic…),
- descriptions of the trades and the functions (work with ideas, facts, people, objects),
- descriptions of the establishments and specialties,
- laws of interaction of these sets.

The footbridges, shunting, joint bases, multidisciplinary formations are rendering this application an intellectual difficulty, cognitively convincing, one. When combinatorics develops plenty of solutions, a margin for more realism is introduced

The modes of reasoning used as regards analysis of orientation advising as well as the nature of knowledge of the education system (incomplete, evolutionary, empirical, qualitative...) indicate that a conventional data-processing solution is less adapted than a Knowledge Based System

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(KBS), which requires the methods of acquisition of knowledge to collect, structure then formalize knowledge to be exploited. Knowledge engineering is a constructive activity aimed to model knowledge through coupling between socio-technic and data-processing artefacts, allowing to build systems facilitating the professional work of the actors. The principal objectives assigned are the apprehension of the behaviour and its comprehension by the user and the development and the installation of a real step of engineering.

The Expert Decision Support System (EDSS) usage paradigm consists of following three steps. the first step in using an EDSS involves an interactive analytical modelling session to aid in information and context gathering. the EDSS presents series of displays in response to questions asked by a user to specify information in advance. instead, they use the EDSS to find the information needed to generate a solution[1].

Modelling: The knowledge base:

- is based on a static descriptive knowledge, formed of classes and objects,
- is articulated by a cluster of know-how of rules
  - organizing the dialogue
  - building acceptable solutions
  - evaluating them to extract the satisfactory solutions[2].

Knowledge organization: In order to describe establishments, consultants, professions and trades. the main classes of knowledge acquisition techniques are described briefly below. Knowledge acquisition is seen as a crucial problem concerning the success of an expert system and has always been regarded as the bottleneck in developing expert system[3]. The process of Knowledge Acquisition (KA) is very time-consuming and difficult. So for acquiring guidance or school/university school knowledge, a multiple KA techniques has been adopted in this project, consisting of many components: interview expert, questionnaire, the multidimensional evaluation, develop a system,...

The multidimensional evaluation

Aim: to identify from concepts or the unknown criteria of discrimination by the psychological technique of proximity[4].

The expert provides for each possible pair of objects a coefficient of proximity or similarity, coefficients consigned in a matrix of similarity which is used as entry with a phase of analysis and raises the criteria or dimensions that the expert will use to establish the coefficients of proximity[5]. Particularly adapted to discriminate between (classes of) objects.

The repertory grids: The *cognitivist* (Knowledge engineer) proposes to the expert a set of objects of the field (generally 3) and asks him to propose a discriminating characteristic, separating the objects in two distinct subsets, relating to this characteristic and his opposite, like (hot and cold) *bipolar dimensions*.

For the choice of a profession, the concepts of classification... in a table [Result * concepts], the expert notes the objects to be classified for each criterion on an arbitrary scale, from 1 to 10 by instance, where 10 represents the characteristic or its reverse *evaluation grid*.

Characteristics	Technician	Agronomist	University
short/long studies	2	5	10
Salary	2	6	5
Responsibility	2	6	4

The production rules can be generated starting from this grid and we may balance the scores of each cell of the table.

Interviews, observation and protocol analysis: All tech-niques demand direct interaction with experts through retrospective or current inquiry. In the retro-spective interview, the expert narrates a memory of how a problem was s olved. The description is commonly rationalized and omits many crucial details. In concurrent interviewing via observation and protocol analysis, the expert verbnalizes his reasoning during the problem-solving process while it is being recorded and observed. The collected information is imperfect and needs some other techniques[6].

Interview experts in guidance field: Many experts has committed themselves to the project as the domain experts. That is not knowledge engineer to provide engineering assistance but we sometimes met some experts to understand their skills, methods and elicit their professional experience. This resulted in a large pool of data of data being collected in describing preferences of users (student, parent..), desires of formations , hopes of trades ob struction in formation and the relations among them.

Questionnaire: It is used to elicit the extend experts, user end and heads of school, university used subjective during the guidance process. It is useful complementari-ties for expert interviews on the consistency and accuracy of counsellor orientation knowledge. This method useful to identify the population and define the questions during the process and to consider other additional list of propositions to find the best way in life .

Collecting cases: A general label for all techniques that exploit recorded cases in knowledge acquisition, such as scenario analysis, recovering of events and the analysis of legacy cases for use in case-base reasoning systems.

Extracting cause-effect relations: This includes tech-niques used to extract causal relations among concepts of the domain. Repertory grid, knowledge graphs and conceptual graphs belong in this class.

Identifying the reasoning pattern: Problem-solving methods and inferences structures are graphical represen-tations of the inference process involved in problem solving.

Categorisation/classification: Classification techniques aim to identify the terms and concepts of the domain and how these concepts and organized in classes, groups or components, according to the expert.

In both diagrams, we present the classification of the consultants Fig. 1 then of the trades Fig. 2.

In the first one the various actors may question this knowledge base. Hence, there is a method of resolution for each case. This classification enabled us to establish an exhaustive list of all individuals who are: high-school pupil, student, engineer, person in charge (headmaster, school inspector…), relative, administrator of the knowl-edge base, handicapped people, others (the list is not exhaustive).

Working out i600 trades, we divided them into 14 classes: Arts, Sciences, Nature, Protection, Technology, Industry, Administrative, Sale, Services, Social sciences, Business, Sport, Computer Science, Internet, 54 sub-classes.

In Fig. 3 second classification, we quoted the various secondary establishments (pre-academic and academic and postgraduate and even the adapted establishments).

Steps of the counselling

- express diagnosis of the starting situation;
- specification, identification of the objectives (impera-tive, wishes) and of the constraints;
- search for the best solutions among the acceptable solutions (resolution of the problem).

Development of CORUS: Since CORUS is an expert system, it must contain knowledge from an expert in guidance field, the knowledge is the core component of any expert system. Efficient knowledge acquisition and representation are one the central challenges for the successful construction and following use of knowledge-based systems in education.

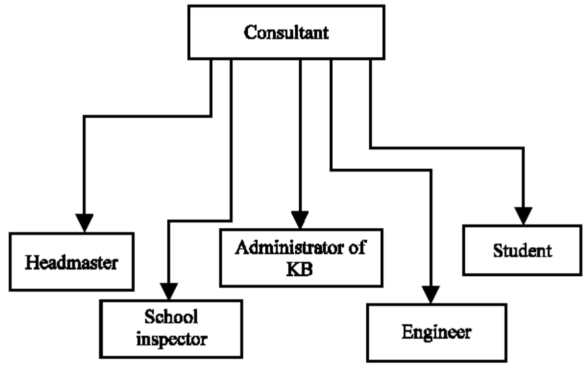

Fig. 1: Classification of consultants

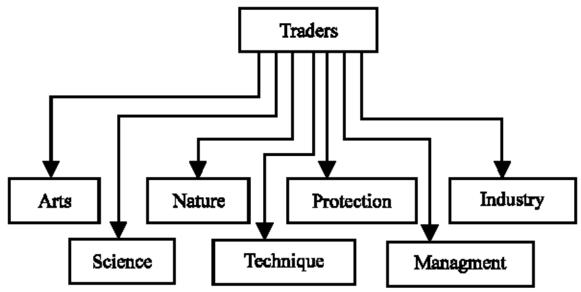

Fig. 2: Classification of trades

Principle: CORUS rests on strategies of combination, stepping and comparison of the specialties to lead to satisfactory solutions (rather than optimal), answering the whole of the constraints or characteristics imposed in the choice of a formation leading to an employment or a given trade, taking into account the possibilities which are offered to the consultant. The system works out a signifi-cant number of acceptable solutions, of which it extracts a limited number of relevant solutions by m-ulticriterion choices[7,8].

Evolution of CORUS: Each major version (1998/1999/2002) has been defined and was built with a duly validated precise version of Ibn Rochd[9].

The software progressed according to two dimen-sions:

- software dimension: various reliability, ergonomics, assistances;
- cognitive dimension: modelling of the field, defini-tion of the services, seeks and articulation of the strategies, points of methodology.

On the basis of a simplistic version, the passage to the following versions was justified by the extension:

- of the field (introduction of the colleges, professional centres …);
- of the services (easing of the cases, widening of the requests);
- of the interactivity (continuation of screens, dialogues…)
- of the councils shade.

Development cycle: To develop a knowledge base each version is made up of eight stages which are: needs analysis, needs checking, acceptable level of risk, design, acquisition of knowledge, prototyping, realization and validation of the tests Fig. 4.

The building of a Knowledge-Based System (KBS) is carried out according to the spiral model for e-volutive prototyping proposed by Boehm in software e-ngineering[10]. Each version alternates the same steps, lessons from one breeding the specifications of the following. For a version, a simple formal design led to pass from the analysis to the realization. Thus, the system is maintained and grows through changes from the environment, the knowledge we have of it and the usable tools. The main objective of knowledge engineering is to transform the ad hoc process of building knowledge based systems into a discipline of engineering, based on methods and specialized tools. Following the idea of a knowledge level as proposed by Newel, which was further reinterpreted in the context of KBS development by Velde, the knowledge acquisition process has started to be seen as a modelling process, in opposition to the traditional simplistic view that, to construct an expert system, knowledge need only be transformed directly from an expert to some computer[6].

The awareness (presentation of artificial Intelligence) phase does not appear in Fig. 4[11].

The goal is to obtain a more efficient KBS by better structuring the knowledge collected and better managing of the system from start to finish. The knowledge engineer (cognitivist) should organize presentations to all levels of the organisational structure; decision makers can then make informed decisions. It insists on the parts played by different actors (management, expert, cognitivist, end users, or and friendly users and developers) involved in the KBS development. We describe a job of expert.

For the expert, the issues that might arise are as follows:

- The expert may be senior to the knowledge engineer; he is not the really an expert at all. The expert has may difficulties to describe his actual activity or job verbally or to put down on study.

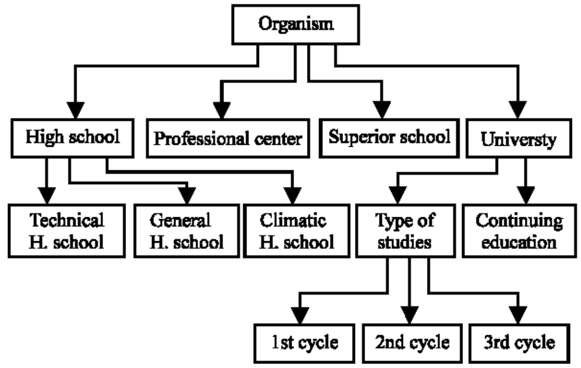

Fig. 3: Classification of establishments

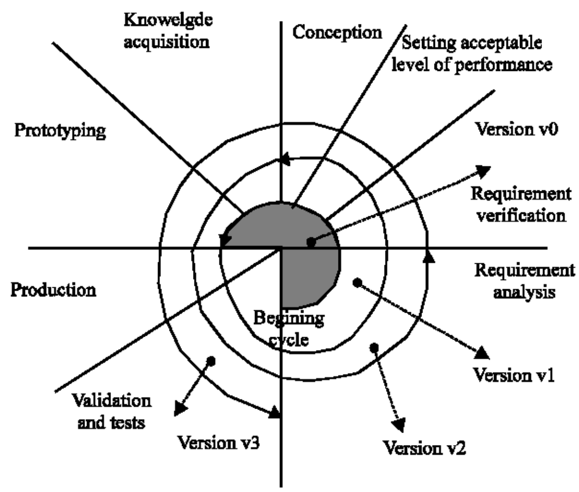

Fig. 4: Spiral model for evolutive prototyping

- The KBS developers need to know how to do knowledge acquisition, how to build KBS in a structured man ner and how to use the chosen programming tool.
- Users must be willing and able to use the system. The ability to use the system can be ensured through train ing typically a day's training. Willingness to use the system is sometimes more difficult to create. It's most important that the users understand the explanation/justification for the system.
- The user interface allows the user to specify all design requirements and acquire the output results from the design consultation .
- The knowledge engineer spends time with expert.

Use of CORUS: A consultation of CORUS uses or combines the following aspects, according to necessary services':

Self-knowledge: Pre-necessary important to plan the formation for a realistic career.

Knowledge of the professions: Access to a knowledge base concerning the professions: tasks to be made, remuneration, places of work, outlets potential.

Knowledge of the work world: Trades or professions advised/disadvised; family, administrative possibilities and of success; requirements of the formation; formation multi-vocation; formations or trades recommended; adapted trades if handicap.

Choice of formation: Helps the user to identify the formations capable of preparing him to given trade. For a given level formation , the user receives the list of the diplomas of this level giving access this trade.

Knowledge of the establishments:

- specialized establishment,
- climatic establishments,
- Establishments approved for the handicapped people, normal establishments with tilted plans and elevator.

CORUS integrates a management of footbridges between the formations (university,..) and manages the compromises between the characteristics and wishes of the people and the requirements of the formations; it offers thus to handicapped satisfactory orientation according to the handicap.

Exploration of the solutions: At the time of the exploitation, the system works out a significant number of solutions, among which it must then propose a limited number (<=5) of relevant solutions. Most of the bases tested returns to the multi-criterion choices.

Principle: Let N be solutions to be evaluated: to each one we associate a "profile ", kind of vector which gathers its "notes ", rightly:

- of one note by criterion if there is little of it;
- of one note by factor (synthesizing auxiliary criteria) if there is much of it.

To each order on the profiles, derived from the orders on the notes, corresponds a pre-order on the solutions:

- two solutions are equivalent if they have equal profiles;
- Unanimous order (partial): a profile is better than another if it is at least also good for each note.
- collating sequence (total): a profile is better than another if it is better for the first note or with equality for this first, better for the second or with equality for the second, the best for the third one…

Total orders are regarded as brutal: they provide from the start equivalent or better solutions. But we can seek a more complex solution (Example: with the deliberations of the jury, a student being noted as[12,13,9] if he has 12 in math, 10 in language, 8 in music, who is the best? A lexicographic order (math > language > music) gives an immediate classification, affirming that[12,13,9] is strictly better than[11,14,15], which may be challenged [Fre 02].

Among profiles and solutions, the partial orders induces a partition between dominants and dominated: any solution is dominated for which there is at least one which is at least also good for each criterion; is dominant any solution which is not dominated. The dominant ones are known as "Paretto-optimal": for each one we can find a better solution on such a criterion, on the condition of accepting a weakening on one or more others criterion.

We call arbitration the process which, by means of a function of interest, makes it possible to order the domi-nant solutions, and thus concretizes a final compro-mise inter-criteria. The weighted sum is the simplest case for the function of interest, but this function may be non-linear, provided that it is monotonous.

To assist the multicriterion choices, a decisional language of representation of knowledge (KRL) s hould make it possible:

- the constitution of a Short List (at start, a short list L is void; the first solution join it ; a new solution S com-pared with a short list L is rejected if it is dominated by a solution of L ; else, S is in tegrated to L, purged from solutions that S would dominate);
- sorting of a short list according to a function of interest (balanced sum, nap of square, product…).

The use of partial orders makes it possible to distin-guish the constitution from the short list like an "objec-tive" preparatory part, final aggregation like "subjective" final part reflecting the own priorities of the decision maker: thus, for the choice of a die, the elimi-nated poor specialties, the function of interest could be different for a young brilliant student, a framework which wants to change a die into keeping acquired modules.

In short, a multicriterion choice asks for various stages of search for solutions, by successive refinements:

- the potential solutions satisfy only part of the re-quirements;
- the acceptable solutions satisfy all the Boolean requirements (difficult die, duration of formation higher than four years);

- the dominant solutions are best acceptable solu-tions; they are contrasted, not comparable between them, because of the conflicting criterion used to express wishes, as a short formation leading to a well remunerated employment;
- the optimal solutions are best dominant solutions, following a function of interest depending all the remaining criteria.

Dominant solution: The construction of short lists (or dominant selection) could use rules like:

```
IF $objet1 =/= $objet2
IF $objet1.profil = $profil1
IF $objet2.profil = $profil2
IF $profil1.critère1 = $profil2.critère1
IF $profil1.critère2 = $profil2.critère2
IF $profil1.critère3 = $profil2.critère3
IF $profil1.critère4 = $profil2.critère4
THEN
KILL($objet2)
```

Where $objet1, $objet2 are similar objects, owners of the compared Profils. That supposes the criteria fully ordered, as with the scale { null, low, poor, well, very well, exceptional }. An action WRITE number ($objet), " interesting solutions ", could precede asking for the preferences of the user.

Preferences: Pertinent counsels must fit possibility and desirability. For that, CORUS generally need the system of priorities of the consultant, who will be used to make emerge among the dominant solutions those solutions which are optimal for him, here and now. The seizure of the priorities or preferences could employ a form of the kind below which makes it possible to the user to say that we seek a function in a sector of work 1/industry, 2/agriculture, 3/business, 4/Administration, 5/Teaching, 6/Health, 7/Services, 8/Military Fig. 5.

The advisor can then adopt for example weights of formations 1 (short cycle), 4 (long cycle), 16 (absence of competition), 64 (easy formation), where reason 4 leaves an influence of a criterion on the other, if the criteria are from 0 to 5. A reason exceeding Maximum Value would return to a lexicographical choice.

- The choice of this reason can be guided by the ques-tion: is the classification of your preferences impera-tive (➔ reason 6) or indicative (➔ reason 4 or 3). A good policy is then to post the 3 (5) better solutions, if possible with accompanying notes.

Fig. 5: Screen copy of inferences

- Another possibility is to sort out the best solutions initially, using an imperative hierarchisation, then to propose in complement the best solutions if this hier-archy is slackened (➔ search for a weaker rea-son (>1) giving another classification, the hierar-chy of the preferences being more indicative).

This box makes it possible to the user to choose an order for the sectors of work. As when there is a form to be filled, the user answers a series of questions to start the reasoning, by exploiting each answer as well as possi-ble. If it is necessary to compensate one " I do not know", this answer starts a reasoning which is articulated on as-sumptions allowing to generate relevant solutions.

Inter-criteria arbitrage and optimal choice: The used dis-tance for a proximal choice can be assimi-lated to an arbitration function between criterias.

The use of arbitration functions of discriminating shape can increase the qualitative aspect of optimization.

	A	B	C
Mark 1	3	4	5
Mark 2	5	5	5
Mark 3	7	6	5
Sum	15	15	15
Product	105	120	125
Sum of squares	83	77	75

- On arbitrage one , I choose A B and C are school equal
- On arbitrage two, banking method: C mini-mizes the risks: it is the case whose min is the most elevated, the "best compromise" (that less dissatisfies)
- On arbitrage three, A has weak points but more of resources (profile of researcher, of blocus forcer …)

Architecture of CORUS: CORUS consists of database (trade), knowledge base (establishment), inference engine, a case acquisition tool (Ibn-Rochd), an explana-tion module and a user interface Fig. 6.

Given the necessary facts and rules (if condi-tions then conclusions), the system can use deductive reason-ing to solve problems. The participants are: the knowl edge engineer, domain expert, users, administrator of knowledge base.

User interface: The user interface allows the user to specify all design requirements and require the output results from the design consultation. The user can monitor the performance of the system during the design process through the interface. In fact, most KBSs, it has been re-ported that a large part of the codes normally deal with the system-user interface. In this prototype system, graphical user interfaces, consisting of layer of display screens and pop-up windows, are used for message transfer so that han-dling has been greatly simplified. Contrary to tradi-tional algorithmic models, the user has control over the sequence of actions during the design process subject to conformance with process control knowl-edge modules[15].

Maintenance: The maintenance of the knowledge base is ensured

- at the factual level (creation / modification / removal of establishments and specialities) by administrators (priv-ileged users)

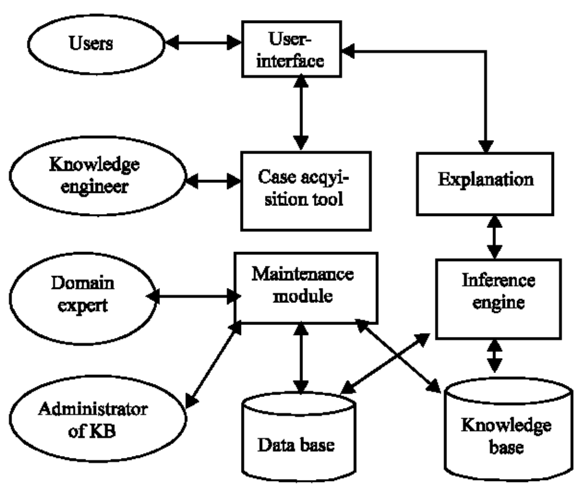

Fig. 6: The architecture Of CORUS

- at the structural level (creation, redefinition and suppression of the types of establishments, diplo-mas; appearances, redefinition or disappearance of t rades), by the knowledge engineer/developer, who deals of (the re) modelling and the adaptation to the new spec ifications.

The current version (v2): To the classes establishments/ specialties/people (v0) were added classes trades (v1) and then solutions (v2).

The current version covers 57 universities and university centres in Algeria, in a whole one hundred establishments; a hundred options; about fifteen bacca-laureates; and comprises 434 objects " trades " divided into 12 classes. For the know-how, it uses 227 rules (1 rule = about 1 screen).

CONCLUSION

CORUS:

- required the use of the multicriterion analysis for a total assumption of responsibility of the prefer-ences, desires and wishes of the consultants as well as obstacles, requirements and characteristics of the formations.
- required methods of acquisition/knowledge organisation such as the interviews (parents, users...) the multidimensional evaluation and the grids of classification.
- Made it possible to release a step of sure design ensuring quality, power and acceptability ; the catalyst which makes these elements a powerful assistant is the capacity with the decision-making.

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