Improving Military Recruit Quality Through Smart Classification

F. Lescreve & B. Schreurs
Belgian Armed Forces – Defence Staff – Personnel Division

1. Introduction

When a company wants to hire personnel, two different situations can occur: the vacancies for which new personnel are sought can be identical or different. From a selection point of view, the first situation is the easiest one. Some selection criteria can be defined and a simple ranking of the applicants can yield the answer as to who is to be hired. A traditional approach would study the relationship between selection data and performance data of hired applicants and develop a regression model for instance. The applicants with the best-predicted performance would be hired.

In the situation where persons have to be recruited for a set of different vacancies, things can get more challenging. Let's assume that the required abilities to perform well in the different jobs are overlapping and that the applicants are willing to accept more than one job to be hired for. This is a typical situation in military recruitment settings. In such situations, dealing wisely with the available abilities in the applicant group and the required abilities for the different vacancies can yield results that are far superior to the ones obtained with simple methods.

This second situation will be discussed in this paper. The *Belgian Armed Forces' Psychometric Model* is specially designed to deal with such situations. It therefore will be referred to throughout this paper.

2. Problem definition

a. The fundamental question

The object of the present paper is each situation in which there are a number of persons who are willing to enlist for a number of jobs. This situation occurs prototypically in most selection and classification contexts where a number of jobs are available and a number of candidates apply for them. But the same type of decision-making process also occurs within organizations whenever one or more jobs or positions have to be manned and there are personnel members interested or at least available to fill them.

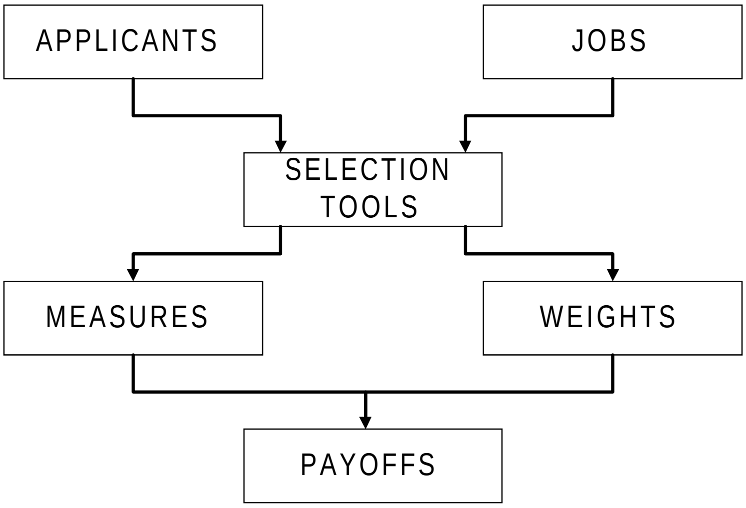
In most practical situations the sketched situation will require some kind of decision making as to **who** will be hired to fulfill **which** job. This is essentially what happens through the selection and classification process. Selection refers primarily to the question whether an individual is qualified or not to fulfill a certain job. Unqualified persons will then be rejected while the qualified ones can be ranked according to the measurement of their qualification. The ones who are best ranked can then be hired. Classification on the other hand is required as soon as different kinds of jobs are involved simultaneously (multiple job environment) and as the candidates are applying for different jobs. Classification systems typically try to quantify the utility of assigning an individual to each particular job and use classification algorithms to decide which applicant will get which job and which applicants won't get a job at all. Clearly, the classification methodology is more generic than the older selection approach, or as Bill Alley[1] from the Armstrong Laboratory puts it: 'It should be noted that the present-day concept of classification is broadly enough defined to include selection as a special case.'

b. Articulating the problem

(1) The general procedure

In most general terms, we can say that the classification problem involves three sets of information: information concerning the persons, information concerning the jobs and information on how to match persons and jobs. These sets of information need to be combined in order to generate information about the utility of assigning each of the applicants to each of the available jobs. The next figure illustrates how this utility (or payoff) can be obtained. An important step is to recognize that both applicants and

Batch classification model



jobs can be linked through selection tools. When an applicant takes a selection tool (a test for instance), this yields a measure (test score). On the other hand, jobs can be distinguished by specifying how important the attribute measured by the selection tool is to perform well in the job. By giving a weight to each attribute measured by the selection tools, a specific job-profile is defined. Combining the measures of a particular applicant with the weights given to a specific job yields the payoff of assigning this applicant to this very job.

(2) Organizational options

The general organization of a selection and classification process has a fundamental impact upon its data modeling and processing. We'll briefly review some of the possible options and their consequences for the data modeling.

(a) Single-tier versus two-tier classification strategies

[1] ALLEY, W. E. (1994) Recent advances in classification theory and practice. In M. G. Rumsey, C. B. Walker & J. H. Harris (Eds)., *Personnel selection and classification*. Hillsdale, New Jersey, Lawrence Erlbaum Associates, Publishers. p. 431

As denoted by Melody M. Darby et al[2], a single-tier classification strategy assigns applicants in one step where each applicant receives an assignment directly to an occupational specialty. A two-tier strategy assigns a proportion of applicants directly to specialties and a proportion to occupational areas in the first step. In the second step, applicants with occupational area assignments from the first step are given specialty assignments in the second step. Thus, a single-step assignment strategy employs a single classification algorithm while a two-step strategy must employ two separate classification algorithms, one at the first step and a second algorithm at the second step.

In the Belgian Forces, the S&C systems are basically single-tiered but there are exceptions such as the NCO selection for Army non-technical specialties. These NCO are first assigned to the 'Army non-technical' occupational area and are only assigned to specialties such as the Infantry, Armor, Artillery and so on after a basic military training of about four months.

For the data modeling issue, the consequences of the choice between a single and a two-tiered strategy can be reduced by considering a two-tier system to be made of two independent single-tier systems. The typical reason to use a two-tiered system lays in the fact that additional data that are only obtainable after extended evaluation periods (such as boot camp or initial courses) are estimated to be necessary in order to make the final assignments to specialties. The person-data required for the second step in the two-tiered strategy will therefore consist of original selection data supplemented by assessment data of the individuals during the evaluation period mentioned earlier.

(b) Batch versus sequential classification algorithms

A second important choice to make when designing an S&C system is whether it is necessary to take a decision concerning the assignment of an individual immediately or not. With the term immediately, we mean at the moment that the applicant finished taking his tests, interview and so on and still is at the selection center. This includes that it is not possible to compare all applicants assessed during a certain time frame, so an assignment decision has to be made for each applicant one at a time. This is done by means of a sequential algorithm. Such an algorithm compares the individual to either a shadow population or a set of standards (fixed or adapted to the recruitment circumstances[3]) in order to take a decision. The US Navy for instance used the first approach in the CLASP[4] system while the second is in use for the volunteer selection at the Belgian Armed Forces. Batch algorithms work differently. There, the selection data are collected for a large number of applicants and afterwards, an algorithm compares these applicants in order to make assignment decisions. The simplest form of batch algorithms is the sorting of the applicants according to a single criterion. From a theoretical point of view, sequential algorithms are less powerful than batch algorithms because they don't work with the exact population of available applicants.

(c) Other options

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[2] DARBY, M. M. et al (1996) *User manual: The Generic Assignment and Evaluation Simulator (GATES).* Armstrong Laboratory/Human Resources Directorate - Technical Paper - 1996-0001, U.S. Air Force., p17.

[3] LESCREVE, F. J. (1994) Some Innovations in the Methodology used for Selecting Belgian Volunteers. In *Revista de Psicologia Militar*, Centro de psicologia aplicada do Exercito, Lisboa, 1994.

[4] KROEKER, L. P. & RAFAEZ, B. A. (1983) *Classification and assignment within Pride (CLASP): a recruit assignment model.* NPRDC TR 84-9 Navy Personnel Research and Development Center, San Diego, California 92152

All combinations of the presented options are theoretically possible, however the use of a sequential algorithm in a second tier doesn't make that much sense and it is no wonder that we couldn't find an actual example. Next table summarizes the mentioned possibilities and gives examples of such systems.

Tiers	Algorithm	Example
1	Sequential	US NAVY, Belgian Volunteers
1	Batch	Belgian Officers
2	Sequen. - Batch	US Air Force
2	Batch - Batch	Belgian NCO (Army non-technical)

Quite a number of other possible options have an influence upon the required data modeling. These include for instance the use of job-quota, priorities for filling certain jobs first or with the best applicants, priorities attributed to certain applicants (for instance applicants who already are in the military), minority fill rates etc. We won't go into details concerning these types of options since the model we'll develop is intended to be sufficiently generic to be able to cope with these particular settings.

In summary, what we are about to describe further is the generic batch classification system used by the Belgian Armed Forces.

3. Method

In this section, we'll describe the 'Belgian Armed Forces' Psychometric Model' briefly. The development of this generic Model started in 1992 and is in effective use since 1995.

a. The Model definition

In the Model definition phase, all elements that will be used by the Model have to be defined. These include:

(1) The selection and classification variables (both metric and categorical);

(2) The vacancies;

(3) The selection criteria and weights for the different vacancies

b. The applicant data

When the Model is defined, the applicant data can be added. All data for all candidates has to be added to the Model. The Model accepts data in MS Access database format[5]. Once the required database tables are imported, the Model verifies whether the required data is present and complies with the given maxima and minima specified in the Model definition.

c. The payoff computation

The next step consists of computing the payoff for all possible applicant-job combinations. This is achieved using a generic formula consisting of three parts: an additive part allowing for the introduction of a general linear model, a multiplicative part permitting the use of

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[5] More details on how the data are presented to the Model can be found in Lescreve, F. *Data modeling and processing for batch classification systems.* in Proceedings of the 39th Annual Conference of the International Military Testing Association, 1997, p 261-268

coefficients for categorical data and a third part intended to correct the payoff for the expressed preferences. This is the generic formula:

$$Y_{ij} = (\sum_{m=1}^{u} \beta_{mj}.X_{im})(\prod_{c=1}^{v} \gamma_{cij})(\prod_{p=1}^{w} [((X_{ijp}/X_{Maxjp}).\varphi_{pj})+(1-\varphi_{pj})])$$

Y_{ij} is the payoff-value of person i for job j;
m (1 to u) represent the metric variables;
β_{mj} is the weight given to variable m for job j;
X_{im} is the score of person i on variable m;
c (1 to p) represent the categorical variables;
γ_{cij} is the coefficient given for job j to the category of variable c to which person i belongs;
p (1 to w) represent the variables concerning the preferences;
X_{ijp} is the expressed preference of person i for job j on variable p;
X_{Maxjp} is the scale maximum of $X_{ijp.}$ The reason why this is required, is to obtain a maximum value of 1 for the expression X_{ijp}/X_{Maxjp} ;
φ_{pj} is the weight given to preference variable p for job j;

The multiplicative part and the part referring to preferences are optional. The additive part is required but can be replaced by a constant valid for all persons if necessary.

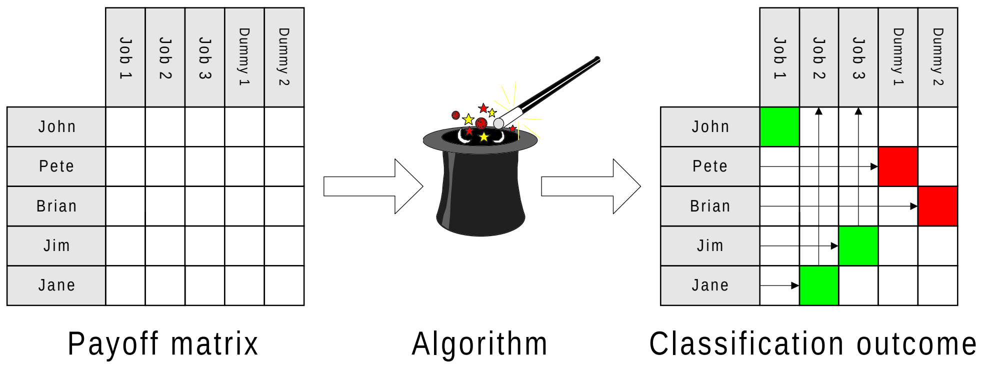
This formula can deal with rejection due to categorical data or preference data but not with rejection as a result of non-compliance with minimum or maximum values for metric data or zero preferences. In these cases a previously computed payoff will have to be set to zero.

d. The matrix optimization

The output resulting from the payoff computation is a matrix in which each cell indicates how desirable it is to assign the applicant in the row to the job in the column[6]. The solution to our S&C problem is obtained by maximizing the sum of the payoffs in the cells linking an applicant to a job (the green cells in the right matrix). Since in most S&C situations, there are more applicants than jobs, the matrix has to be squared by adding dummy jobs. Applicants assigned to those dummy jobs are rejected (the red cells in the right matrix). .

[6] Of course, the necessary standardizations are performed during the whole process to ensure that data can be compared.

Batch classification model



The algorithm needed for the matrix optimization is one derived from the so-called Hungarian method to solve the traveling salesman problem. Several possibilities are available such as the Ford Fulkerson algorithm for quota or Linear Programming (LP). The algorithm we currently use is the one developed by Burkhard, Derigs et al.

This approach guarantees that the best possible classification is reached, given the measured attributes of the applicants and the expressed desirable attributes for the jobs.

e. The immediate quality assessment

One of the major advantages of batch classification is that the quality of the reached solution can be assessed before the applicants are informed about the outcome. The complexity inherent to a batch classification system makes it rather inappropriate to summarize its quality by a single overall value. In many cases the practitioner will be better off with a series of indicators each focusing on a specific aspect of the classification quality. Such indicators are indeed available and can be grouped according to the moment at which they can be obtained.

Some indicators depend on data that are not available at the time the classification algorithm is performed. These criterion data typically comprise attrition rates and performance measurements. Quality indicators based on such data include predictive validity coefficients of the payoff-values, differential validity of predictors, logistic regression models against pass-fail criteria, cross checks of the used linear models, etc. Such quality indicators can be called *delayed* or *a posteriori* indicators.

Other quality indicators do not require data that aren't available immediately after the classification algorithm runs. These can be labeled *a priori* or *immediate* quality indicators. These indicators are less powerful than the ones relying on criterion data and cannot provide the practitioner with final statements concerning the quality of the used system, but it offers one tremendous advantage: it allows him or her to modify certain parameters used in the classification model before the assignment decisions are carried out. Put in other words, these indicators allow to detect problems in the classification outcome and to rectify them by altering the parameters of the classification system. The classification model can subsequently be rerun until the classification quality is acceptable. It is only at that time that the applicants are informed of the outcome.

Following immediate quality indicators are included in the Psychometric Model[7]:

(1) The Fill rate

(2) The Mean Predicted Performance (MPP)

(3) Descriptive statistics for the groups assigned to the trades

(4) Respect of the applicants' preferences

(5) Respect of the requested job profiles

(6) Specificity of the requested job profiles

f. The output

When the quality of the reached classification is considered acceptable, the results can be communicated to the applicants. For that purpose, the Model provides the user with a number of possibilities: lists can be printed or database tables can be exported for further use.

A situation to which the practitioner can be confronted is that of an applicant that is accepted for a specific vacancy and who decides not to sign on after all. In such a case, somebody else has to be looked for to replace the first one assigned to the job. This is quite easy in the Psychometric Model. Since payoffs were computed for all applicant–job combinations it is possible to rank the applicants according to their payoff for a specific job. That is exactly what happens. When a person was assigned to job x but is no longer interested, the applicants who aren't assigned to a job already, are ranked according to their payoff for job x. The candidate with the highest payoff is then assigned.

4. Results

The results obtained through smart allocation using the Model as described above are consistently superior to those obtained using sequential methods or simple classification methods (such as a unique ranking of the applicants whereby the applicants are assigned to a job according to their ranking and their preferences). It is particularly striking that our classification model on average better respects the preferences of the applicants than by models primarily based on sequential allocation according to the expressed preferences.

5. Conclusions

The experience accumulated over the last decade in designing and applying smart batch classification is so positive that we cannot but encourage practitioners to leave more traditional S&C systems to study and implement more powerful systems that ultimately improve the quality of the assigned recruits.

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[7] For more details, see Lescreve, F. *Immediate assessment of batch classification quality.* in Proceedings of the 40th Annual conference of the International Military Testing Association