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FORCE4/R, A NEW SOFTWARE PRODUCT FOR FORECASTING AND SEASONAL ADJUSTMENT

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In this paper, we briefly describe the functions and the software architecture of FORCE4/R, a time series software that allows easy interfacing with already existing software: TRAMO and SEATS, X12, SCA, and also with statistical software developed at UPC (Polytechnical University of Catalonia) such as IDAUT, IDAFT, CONJUNCTURE and others. In addition, the results of an extensive simulation study to evaluate the quality of FORCE4/R are presented and discussed.

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1. FORCE4/R AND THE FORECASTING METHODS

FORCE4/R is a forecasting, modelling and signal extraction software which is based mostly on the Box-Jenkins methodology [see Box et al. (1994)]. It is part of FORCE4, a forecasting software system that comprises a wide variety of methods (http://www-tqg.upc.es/seccio_tqg/projectes/force4/), which has been developed over the last two and a half years under ESPRIT IV project number 20.704. FORCE4/R allows for manual or automatic modelling of one or more time series and is capable of dealing with outliers, calendar effects, Easter effects, intervention analysis, model based seasonal adjustment, signal extraction, conjuncture analysis and transfer function models.

2. FUNCTIONS OF THE FORCE4/R SYSTEM

The main goal of the system is to allow the end user to model and forecast time series using the best available methods, and taking advantage of the experience that professional users have incorporated into the system.

In what follows, we describe the main functions of FORCE4/R.

2.1. Data base management

The Data base system groups the data by domains. A domain is composed of a set of time series of the same periodicity. It is possible to update, import, etc., time series, and also to access external databases with ODBC.

2.2. Automatic univariate modelling

The system will automatically find the SARIMA model (p, d, q) (P1, D1, Q1)s1 $\times$ (p2, D2, Q2)s2 $\times$ (P3, D3, Q3)s3 $\times$ (P4, D4, Q4)s4 that best fits a given time series.

This function can be performed with two different methods. One is based on software developed at UPC (IDAUT) which identifies a tentative model within the SARIMA class using a Mahalanobis type of distance between the theoretical ACF and IACF and the sample equivalents together with a search algorithm. The degree of differencing is also identified. The second method uses the automatic modelling capabilities of TRAMO.

Estimation of parameters and diagnostic checking can also be carried out either by using SCA and an expert system with rules implemented by UPC in KAPPA, or using TRAMO. Some of the parameter rules can be modified by the expert user.

2.3. Possibility of the automatic elimination of outliers

Additive Outlier (AO), Temporary Change (TC), and Level Shift (LS) type outliers can be eliminated automatically by SCA or TRAMO.

2.4. Intervention analysis

The impact of external events can be determined. These events may be of different types: labour strike, promotions, price increases, etc. This is done by the introduction of binary variables with various filters that will affect the time series (intervention analysis).

2.5. Transfer function analysis

The system automatically identifies, estimates and verifies the transfer function model between the time series Y_t and X_t.

2.6. Manual modelling

The system allows manual input of any univariate model or intervention model that the user may wish.

2.7. Forecasting

The system performs forecasting using any one of the previously adjusted models, and batch forecasting of a group of series. It also monitors the forecasting errors of the model by means of CUSUMS of the forecast error and EWMA.

2.8. Seasonal adjustment

The system allows the decomposition of a time series into trend, seasonal component and noise using the adjusted model. For this, the user can choose between X12/ARIMA and SEATS.

2.9. Conjuncture analysis

This analysis is performed following the methodology developed by Espasa (1993).

First the system performs seasonal adjustment using X12 or SEATS, and then it calculates relevant statistics for conjuncture analysis, such as underlying trend, conditional and unconditional rate of growth, inertia, etc. and allows the user to visualise the results in different graphic settings.

2.10. Configuration

It offers a wide range of possibilities with regard to definition of the methods and statistical package to be used, the parameters of the rules of the expert system, etc.

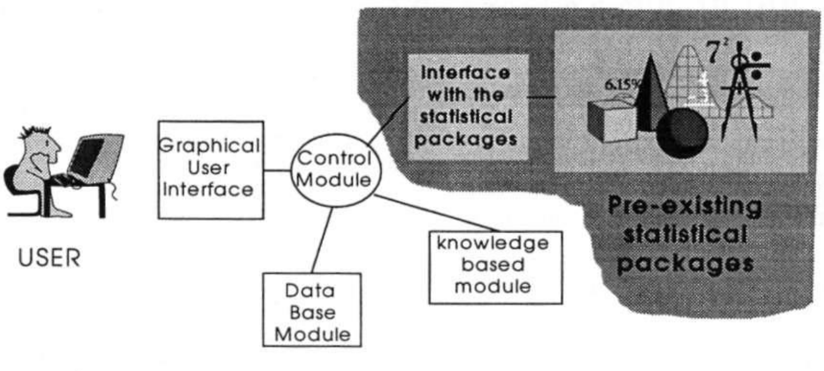
Terminology on time series analysis can be found in Box et al. (1994). Some references on statistical packages are given at the end of this report.

3. ARCHITECTURE OF FORCE4/R

FORCE4/R has been designed with the main objective of separating the user interface from its underlying application subsystem. This provides a flexible framework that allows substitution of some of the statistical packages when desired, together with straightforward, easy introduction of new functions.

With this intention in mind, the ARMAG architecture [see Prat et al. (1994)] was adopted as the basis for the development of the FORCE4/R architecture, and the different components that will compose the complete system were identified and defined.

The following figure shows the FORCE4/R architecture and the components of the system.



In the figure above, we can distinguish:

- The GUI, Graphical User Interface, is the software component responsible for the management of the surface-level human-computer interface, which also includes the strategy of the system.
- The Communications Control and Logging Agent (or Control Module) deals with the management and co-ordination of communications between all the components, which is achieved through a messaging protocol.
- The BEM [Back-End Manager, see Prat et al. (1992)] interfaces the pre-existing statistical packages integrated within the system. The statistical packages used in the FORCE4/R system for performance of the statistical functions are: IDAUT, IDAFT, CONJUNCTURE, SEATS, TRAMO, SCA and X12/ARIMA.
- The knowledge based component contains a set of rules which are used to analyse the results of some of the statistical packages used as back-ends, applying the knowledge of the experts consultants. The KAPPA shell (Intellicorp) is used for this function.
- Data Base Management: developed with ACCESS (Microsoft), although an ODBC connection will be implemented in a second phase.

The link between all the different modules is provided by the nucleus of the ARMAG architecture, which gives the user the impression that he is working with a single system. In other words, FORCE4/R is an example of the creation of a sophisticated system from different and separable elements, using the most appropriate tool available on the market for each component. Developing and/or customising a component is the responsibility of the expert associated with it.

The system is open in the sense that it is possible to specify the desired models instead of using the ones selected by the system, to import/export series, to change certain rule parameters, and in the case of professional users, it is also possible to add or change rules.

Finally, for the «developer»-user, it is possible to add new methods and/or statistical packages, modify interface knowledge with the packages (BEM) and modify the user interface (programmed in Visual Basic).

4. EVALUATION OF THE SYSTEM. SIMULATION STUDY

4.1. Testing and evaluation

Several approaches were followed for the testing and evaluation of the FORCE4/R system:

- In-house testing and evaluation
- Beta-test users
- Presentation to large audiences

The in-house testing and evaluation comprised two different procedures:

- Normal test procedure
- Simulation study

The first procedure involved creation of a test-bed set for the testing of the successive versions of the system. Several time series from the literature and others that were carefully modelled by the experts at UPC were used to check the incremental versions of the system.

The second procedure, described in detail in the following sections, consisted of rigorous work on designing and executing a test involving the simulation of approximately 20,000 series following different ARIMA models, and then checking the results obtained for the different methods included in the system.

The beta-test approach involved search and selection of beta-test users. We tried to find a broad spectrum of different kinds of beta-test users, covering institutions, services and industry organisations. In general, the beta-test users selected analysed a large number of series, and provided us with very useful feedback.

It was necessary to set up a procedure for compiling and recording problems and suggestions, deciding which ones were most important, and re-designing, if necessary, the system. In some cases, re-design was considered appropriate.

4.2. General description of the simulation study

The aim of the study was to compare the two time series modelling methods available in the FORCE4/R software (TRAMO-SEATS and IDAUT-SCA).

The procedure consisted in simulating univariate time series following predetermined ARIMA models, and then assessing the methods' performance by comparing the output model with the original, according to several statistical measures.

The simulation process is carried out by an algorithm which runs the SCA software in order to obtain a vast range of ARIMA models by simulation. The SCA takes as inputs the mean and variance (as a percentage of the mean) of white noise process and the parameter values of a chosen ARIMA model and simulates a time series of a chosen number of time series data.

The time series that are simulated belong to a range of ARIMA models with the following maximum orders: (p=3,d=2,q=3)×(P=2,D=1,Q=2)$_{12}$. Given a specific ARIMA model, different parameter values are used to simulate several time series: four different values belonging to $|\phi_1| < 1$ for either first-order autoregressive and moving-average processes; for second-order autoregressive and moving-average processes, four pairs of values (ϕ'_1, ϕ'_2) belonging to the admissibility region, two of them corresponding to real roots and the other two to complex ones; and for third-order autoregressive and moving-average processes, the range of values is the result of all the possible combinations of the values above: $(\phi''_1, \phi''_2, \phi''_3) = (\phi_1 \times (\phi'_1, \phi'_2)$, therefore there are sixteen possible values. However, when simulating ARIMA models:

$$\phi_p(B)\,\Phi_P(B^{12})\,\nabla^d\,\nabla_{12}^D\,Z_t^\lambda = \theta_0 + \theta_q(B)\,\Theta_Q(B^{12})\,a_t$$

the parameter values of the two terms (autoregressive and moving-average) must not coincide, otherwise the order of the simulated model would become smaller.

On the other hand, the algorithm simulates time series with and without constant term θ_0 and with and without the logarithmic transformation of the original data.

The next step consists of modelling all the simulated time series with the two alternative softwares and obtaining a model for each series. The models are then saved in a data base.

Finally, the accuracy of the different methods is assessed by comparing several measures of forecasting performance, such as the percentage mean absolute error (PMAE), the root mean squared error (RMSE) [García-Ferrer et al. (1997) and Ruiz et al. (1996)] and the distance between the π weights [Piccolo (1990)].

The first results of this study show that:

1. The model obtained by TRAMO and by IDAUT plus SCA is a valid model in approximately 90% of the time series.
2. The PMAE and RMSE obtained by the two methods is at most 5% greater than the corresponding values obtained using the true model in about 65% of the cases (65%-60%).
3. TRAMO execution is five times faster than that of IDAUT + SCA.

5. CONCLUSIONS

If it is to be competitive, European industry needs systems that provide rigorous forecasts of demand. Forecasting researchers and professionals need to optimize their time in performance of their normal work. The system presented in this paper makes it possible to use sophisticated methods and powerful statistical packages with a high degree of ease, and also to intervene at a low level if desired. Various organisations that acted as beta-testers in a validation study carried out during the last stages of the FORCE4 project (FIAT, HESPERIA, Caixa d'Estalvis de Catalunya, Institut d'Estadística de Catalunya, Instituto Vasco de Estadística and others) agreed with this assertion.

The results of the simulation study comparing the different methods included in the system show it to be reliable.

It is planned that different forecasting systems will evolve from this open expert system. One of these is FORENET [Prat et al. (1997)], a commercial system, having a back-end (an algorithm) based on application of the genetic algorithm and neural network techniques, and distributed in Spain and South America by BBS (Best Business Systems).

Technical details and licences

The system runs on the Windows platform (Windows 3.1, Windows 95 and Windows NT). It requires at least a Pentium 200, 32 Mbytes of RAM memory and 10 Mbytes of hard disk space.

A licence for the use of the system can be obtained from UPC (at the same address as given at the head of this paper). This licence covers the cost of the different packages and authorises use of the system in two different computers.

Statistical package references

IDAUT: Identifies the model using the distance between the ACF and IACF of the theoretical model and those of the given time series [M. Valls i Colom (1983)].

IDAFT: A system that allows identification of the transfer function based on the Corner Table, computation of the standard deviation, and determination of the elements that are statistically significant, by using the recognition algorithms to determine the transfer function. Developed at UPC.

CONJUNCTURE: Developed at UPC following the methodology of A. Espasa (1993).

KAPPA: A shell for the development of a knowledge based system, from Intellicorp.

SCA: Statistical System. Software for Forecasting and Time Series Analysis, from Scientific Computing Associates.

SEATS: Signal Extraction in Arima Time Series, from V. Gómez and A. Maravall (1992).

TRAMO: Time Series Regression with Arima Noise Missing Observations and Outliers, from V. Gómez and A. Maravall (1992).

X12/ARIMA: Decomposition of a time series into trend, seasonal component and noise, from US Bureau of the Census.

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