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# Smart Agents and Multimedia Systems

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## Motivation :

## Reasons for Multimedia

— Comprehension

* " A picture is worth a thousand words."

— Attention / Retention

* Sight, sound & motion

  hold the user's attention & enhance recall

  compared to a single sensory mode

* Possibility of interactivity →

  active involvement of user

  rather than passive viewer

## Key issues in Multimedia

- Content vs. Medium
- Representation
  - Text
  - Graphics
  - Image
  - Audio
  - Video
  - Animation
- Hardware Technologies
  - Storage
  - Communication
  - User interface
- Industries
  - Consumer goods
  - Computer hardware
  - Communications
  - Broadcasting
- Social & Legal Issues
  - Intellectual property
  - Regulation
  - E.g. Video-on-demand by cable TV vs. telcos

# Types of Data

— Text

— Graphics

— Image

— Animation

— Audio

— Video

## Communication Media

- Telephone
  - ADSL (Asymmetric Digital Subscriber line)
  - 1.5 Mbps ~ 6 Mbps
- Coaxial cable
  - Cable TV
  - LAN
- Optical fiber
  - B-ISDN
- Satellite
- Wireless / Cellular

## Data Compression

- Reduce storage requirements
- Lower transmission time
- Cut costs
- Types of comprehension
  - Lossless coding

    2:1 or 3:1 comprehension
  - Lossy coding

    quality depends on amount of loss

## Compression Standards

- Joint Photographic Experts Group (JPEG)
  - For continuous-tone images
- Moving picture experts group(MPEG)
  - For cinematic films
- CCITT H.261
  - For video phone & video conferencing
- Joint Bilevel Image Group (JBIG)
  - For binary images
- Multimedia Hypermedia Experts Group (MHEG)
  - For data synchronization & data link layer

## Applications of Multimedia

— Education

* Computer Aided Instruction (CAI)
* Elementary & junior education
* Professional training

— Information

* Product data

  E.g. Home shopping
* Digital maps
* Point of information (kiosks)
* Integrated text, images, etc.

— Business

* Email

  E.g. MIME
* Presentations
* Video conferencing
* Publicity

— Entertainment

* Interactive games & books
* Video on demand

## Intelligent Multimedia Systems

- Why

  — Material is being loaded into cyberspace at a furious rate.

  — Material is in diverse formats : text, audio, video, etc.

  — The same material may be used for different purposes.

  E.g. A picture of an airplane might be designed originally to teach engineers, but used by a safety instructor to point out the locations of emergency exits.

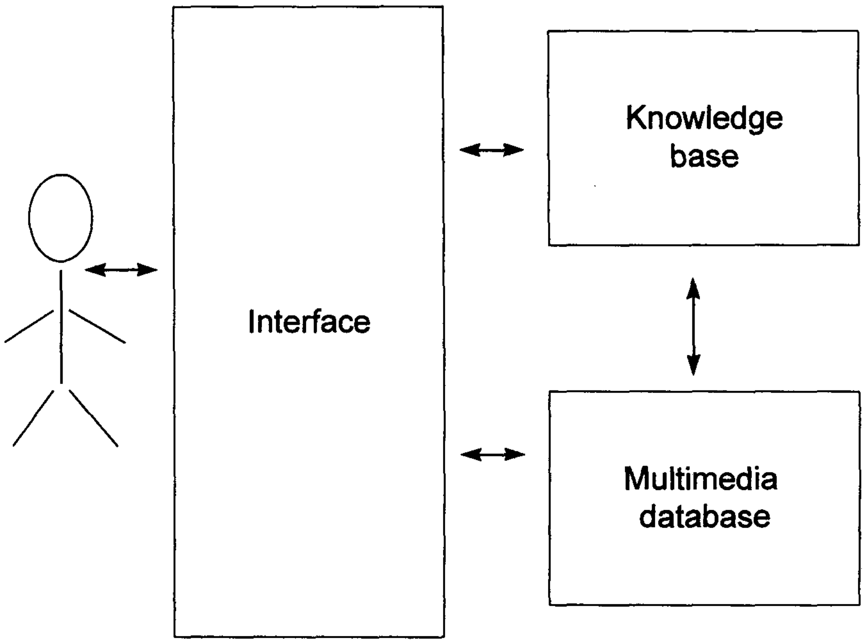
- Goal

  — Smart system can automate :

  * Retrieval of pertinent information
  * Integrate materials for presentation to user
  * Control the sequencing of materials in response to observed user needs

    E.g. Brief explanations to an expert ; extended explanations to a novice.

## Genetic Schematic for an Intelligent Multimedia System



## Intelligent Multimedia Presentation Systems (IMMPS)

- Functions

1. *Compatibility ("effectivity")*

   Coordinating diverse media in a consistant way

   E.g. Linkage between part of an image and explanatory text of that component.

2. *Adaptivity*

   Constructing a presentation dynamically, depending on context.

   E.g. Side explanations of a subtopic unfamilar to the user.

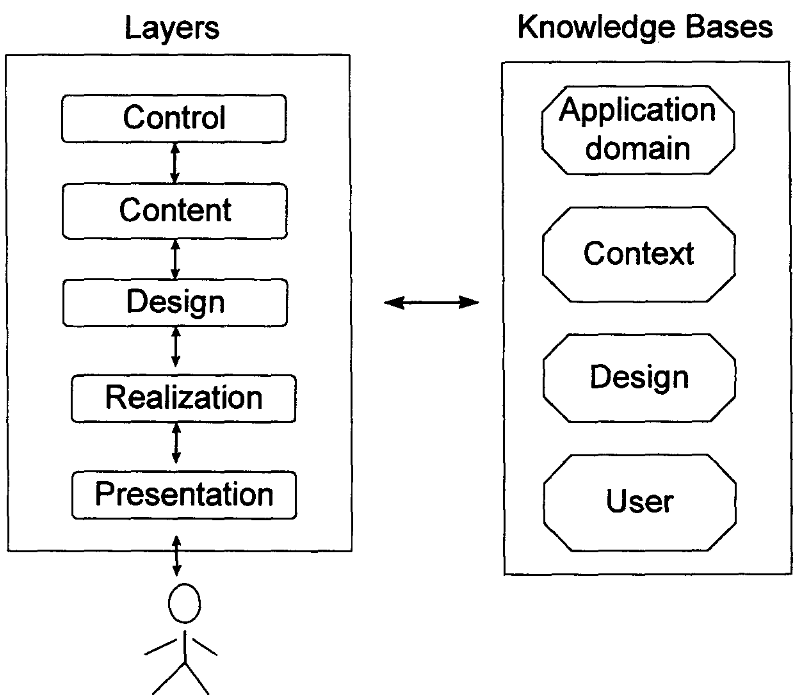
3. *Reflectivity*

   Exphicit awareness of the syntax and semantics of an object.

   E.g. The command " Enlarge the left dial " generates a close up of a particular component in an image.

## Reference Model for IMMPS :

## European Architecture



## Reference Model :

## Layers of an IMMPS

- Control Layer
  - — Handles presentation goals
  - — Responds to commands

    E.g. Stop ; Pause ; Branch.

- Content Layer
  - — Manages high-level authoring tasks

    E.g. Selecting content ;

    Organizing content ;

    Allocating media.
  - — Specifies design tasks for each medium

    & defines how these tasks relate to each other

- Design Layer
  - — Embodies design components for each medium
  - — Components are micro-planners which convert design tasks from Content Layer into plans for objects in various media
  - — Layout design component establishes constraints for spatial & temporal organization of material

## Layers of an IMMPS (cont.)

- Realization Layer
  - — Converts design specs from Design Layer into encoding of information for particular media

    E.g. Rendering components for graphics ;

    grammar or inflection for text

- Presentation Display Layer
  - — Defines the runtime environment for a presentation
  - — Dispatches media objects to output devices

    E.g. Audio to a loudspeaker ;

    Text to a printer
  - — Coordinates tasks among display devices

    E.g. Audio on loudspeaker vs. image on screen

## Applications of IMMPS

- Tutoring
  - — Textbook explanation
  - — Explanation for operating equipment

- Providing information
  - — Information kiosks
  - — Geographical directions
  - — Handling business forms

    E.g. Filling out tax forms

- Design
  - — Configuring computer networks

- Planning
  - — Formulating missions

- Control
  - — Situation monitoring
  - — Project management

# Agents

- **Agent**

  ≡ "A program which acts on behalf of a person"

  ≡ "An autonomous decision making object"

  — In practice, any useful agent will have
  input and/or output
  communication capabilities

  — Agent programming =
  descendant of object oriented programming

- **Types of Agents**

  — Sedentary

  * Sits on a user's PC
  * Monitors the environment for changes
  * May send out a simple request for information

  — Mobile

  * Wanders across a network
  * Seeks information at remote sites
  * May negotiate for its owner

# Agent Languages

- Java

  — first developed at Sun Microsystems
  → taken over by JavaSoft,
  a subsidiary of Sun Microsystems

  — *Java* = object-oriented language for programming agents

  * *interpreter:* Authorizes resources
  → maintain security
  * *byte code:* Similar to C.
  No pointers → robust.
  Compact → travel efficiently across networks

  — *application* = a free-standing Java program.

  — *applet* = an object called by a Java application.

  E.g. An animated graphic.

  — *HotJava* = a Web browser written in Java.

  * interprets formats dynamically →
  automatically accommodates new standards

  E.g. GIF, JPEG formats

- Telescript = object-oriented language
  → agent-based applications

  — developed by General Magic, Inc.

  = an alliance of Apple, AT&T, Mitsubishi,
  Motorola, NTT, Philips, Sony, Toshiba, etc.

  — *Magic Cap* = user interface for applications
  → integrated email, fax, paging, telephone, etc.

  — *Telescript* = object-oriented language
  → agent-based applications

# Rationale for Agents

Purpose: To support human decision making.

- Efficiency
  - — Delegate routine tasks
  - — Perform repetitive tasks more quickly than humans

- Effectiveness
  - — Manage information overload on human users
  - — Replicate human expertise such as
    - * Language translation
    - * Financial analysis
    - * Tax advice
    - * Legal remedies
    - * Others

# Typology of Functions

Software agents emulate the activities
of competent human assitants.

- Gathering data

  E.g. Monitoring the state of financial markets.

- Processing information

  E.g. Providing summary statistics.

  E.g. Identifying turning points in a stock price.

- Extracting knowledge

  E.g. Discovering that a rise in the market index on Friday usually leads to a rise on Monday morning.

- Making decisions

  E.g. Deciding to convert 20 % of a stock portfolio into Treasury bonds.

- Implementing decisions

  E.g. Dispatching buy or sell orders to brokers, then confirming the execution of requests.

# Sample Applications

- News Alert
  - Monitors news from external sources
  - Notifies user of important developments
- Investment Agent
  - Tracks the financial markets
  - If decision criteria are triggered →
    buys or sells securities
- Purchasing Agent
  - Recognizes the need
    for a particular product or service
  - Contacts potential suppliers
  - Identifies the lowest price
  - Negotiates the purchase
- Scheduler
  - Examines a group of users' itineraries
  - Sets up a meeting convenient for all

# Examples of Agents

- *Softbot*

  — Developed by Etzioni at University of Washington.

  — Sorts email by priority and user preference.

  — Schedules meetings by finding a slot
  which is convenient for all parties.

- *Firefly*

  — A product of Agents, Inc.

  — Developed by Patti Maes at MIT.

  — Recommends entertainment for a user.

  * Observe preferences of the user
  * & adds knowledge gained by
    Firefly agents belonging to other users

  $\rightarrow$ offer suggestions on artists, albums, movies.

- Agentware

  — A series of products from
  AutoNomy Corp. of Cambridge, UK

  * Under exclusive license from Cambridge Neurodynamics Ltd.

  — *Press Agent* = a personal electronic newsletter

  * Searches the networks for news
  * Selects articles of particular interest to the user.

  — *Mail Agent* = an email sorter

  * Scrutinizes incoming email
  * Identifies the pieces by priority
  * Notifies the user by fax if necessary

  — Guardian Agent = an automated censor for children

  * Reviews incoming documents
    before they are displayed on the user's screen
  * Forbids files which contain
    seedy language or naughty pictures

# Examples of Agents (Cont.)

- *Open Sesame!*
  - Developed by Charles River Analytics Co.
  - First example of a learning system for the Macintosh.
  - Uses a type of neural network known as Adaptive Resonance Theory (ART).
  - Monitors which applications & documents are used in which sequence by the user
    → offers to automate the sequence.

    E.g. After turning on the computer,
    user reads email, then opens a news feed on a browser
    → *Open Sesame* asks user if he wants the same tasks done automatically.
  - *Open Sesame* requests permission before executing any task.
    After acquiring trust over a period of time,
    user can order the agent to perform certain asks autonomously,
    without seeking permission each time.

# Some Development Projects

- Tasks for learning agents on global networks

  — Prediction of financial markets

    * *Stock market* prediction
      through a hybrid method
      of case reasoning and induction

    * *Interest rate* forecasting
      through complex models
      and statistical analysis

    * *Foreign exhange rate* prediction
      through neural networks &
      multivariate models

  — Re-balancing a portfolio
    based on incoming news

  — Smart execution of market orders
    based on fees and capabilities of vendors

- Application areas

  — Domestic finance

    E.g. Fund management for portfolio investment
    by economic sector

  — International strategy

    E.g. Foreign direct investment in emerging economies

  — Enterprise integration

    E.g. Enhancing productivity in manufacturing intranets

# Introduction to Data Mining

- **Data Mining**

  ≡ "Extraction of knowledge from databases using software tools for information discovery"

- **Role of Software**

  — Automated tools to discover knowledge, and/or

  — Decision support aids to support human decision makers

- **Reasons for the Ascent of Data Mining**

  — Expansion of databases due to decreasing costs of collecting and storing data

  — Consolidation of databases across corporate departments,
  → concept of the *data warehouse*

  — Recognition that large databases contain latent value

  — Need to respond to market forces

  * Accelerating rate of product changes
  * Targeted marketing to micromarkets
  → ultimate goal: customized products tailored to individual consumers
  * Customer demand for swift service in
  — Filling orders
  — Product maintenance & service

- **Data Warehouse**

  ≡ "A large store of data organized in a consistent, uniform format for ready updating and retrieval"

# Areas of Application

- **Marketing & Retail**

  — Discovering general patterns of behavior among consumers based on demographic data.

  — Identifying purchasing behavior by existing customers.

  — Forecasting the potential response by customers to different types of advertising

    * Television
    * Radio
    * Newspapers
    * Direct mail
    * Etc.

  — Decision support aids to support product managers

- **Banking**

  — Identifying credit card usage patterns among different customer segments.

  — Detecting fraudulent usage of credit cards.

  — Predicting "vulnerable" customers who are likely to defect to competitors' credit cards.

- **Finance**

  — Discovering patterns of behavior in capital markets.

  — Generating profitable trading rules based on financial variables.

  — Predicting economic rates of growth for portfolio investment in emerging economies.

  — Forecasting foreign exchange rates for hedging currencies in international trade.

  — Predicting interest rates by country in order to

    * determine where to locate a new facility.
    * decide where to issue corporate bonds to raise funds.

# Areas of Application (Cont.)

- **Insurance**
  - — Predicting which customers will purchase a new policy.
  - — Recognizing patterns of behavior among risky clients.
  - — Identifying fraudulent cases.

- **Medicine & Health Care**
  - — Recognizing patterns of behavior in patients' visits to doctors.
  - — Predicting patients at high risk for particular ailments.
  - — Identifying successful drugs or therapeutic schemes for specific illnesses.

- **Quality Control**
  - — Targeting the combinations of production parameters which lead to specific types of defects.
  - — Predicting the productivity of manufacturing processes based on particular equipment and operating schedules.

- **Transportation**
  - — Recognizing distribution points with high reliability & on-time delivery.
  - — Identifying common patterns in distribution schedules among outlets
    → consolidate deliveries

# Success Stories

- **Nestle Foods**: *Direct Marketing*

  — *Buitoni* = Nestle's leading pasta brand in Britain.

  — *Casa Buitoni Club* = a network of Buitoni customers

    * Club was launched in 1993.

    * Sends out quarterly newsletters with recipes & competitions for holidays in Italy.

    → increased purchases of Buitoni pasta by 15 %.

# Success Stories

- **Kraft Foods**: *Direct Marketing*

  — Company maintains a database of purchases by 30 million customers.

  — Data mining →

  1. Analysts identified associations among groups of products bought by particular segments of customers.

  2. Sent out 3 sets of coupons to various households.

     → Better response rates:

     50 % increase in sales for one its products

     → Continue to use of this approach

- **Health Insurance Commission of Australia**: *Insurance Fraud*

  — Commission maintains a database of insurance claims, including laboratory tests ordered during the diagnosis of patients.

  — Data mining →

  1. Identified the practice of "up coding" to reflect more expensive tests than are necessary.

  2. Now monitors orders for lab tests.

  → Commission expects to save US$1,000,000 / year by eliminating the practice of "up coding".

# Success Stories
# (Cont.)

- **HNC Software**: *Credit Card Fraud*

  ♦ **Payment Fraud**

  — Large issuers of cards may lose
  > $10 million / year due to fraud

  * Difficult to identify the few transactions
  among thousands which reflect potential fraud

  → *Falcon* software

  * Mines data through neural networks
  * Introduced in September 1992
  * Models each cardholder's requested transaction
  against the customer's past spending history.

  - processes several hundred requests per second
  - compares current transaction with customer's history
  - identifies the transactions most likely to be frauds
  - enables bank to stop high-risk transactions before
  they are authorized

  * Used by many retail banks:
  currently monitors
  > 160 million card accounts for fraud

  ♦ **New Account Fraud**

  — Fraudulent applications for credit cards
  are growing at 50 % per year

  → *Falcon Sentry* software

  * Mines data through neural networks and a rule base
  * Introduced in September 1992
  * Checks information on applications
  against data from credit bureaus
  * Allows card issuers to *simultaeously:*

  - increase the proportion of applications received
  - reduce the proportion of fraudulent applications authorized

# Success Stories
# (Cont.)

• **IBM Microelectronics**: *Quality Control*

— Analyzed manufacturing data on
Dynamic Random Access Memory (DRAM) chips.

— Data mining →

1. Built predictive models of

   * manufacturing yield (% non-defective)
   * effects of production parameters on chip performance.

2. Discovered critical factors behind

   * production yield &
   * product performance.

3. Created a new design for the chip →

   * increased yield →
     saved millions of dollars in direct manufacturing costs
   * enhanced product performance by
     substantially lowering the memory cycle time

# Success Stories (Cont.)

- **B & L Stores**: *Retail Sales*

— *Belk and Leggett Stores =*

  * one of largest retail chains
  * 280 stores in southeast U.S.
  * data warehouse contains
    100s of gigabytes (billion characters) of data

  → data mining to:

    - increase sales
    - reduce costs

— Selected *DSS Agent* from MicroStrategy, Inc. →

  * analyize merchandizing (patterns of sales)
  * manage inventory

— *DSS Agent*

  * uses intelligent agents → data mining
  * provides multiple functions

    - recognizes sales patterns among stores
    - discovers sales patterns by

      * time of day
      * day of year
      * category of product
      * etc.

    - swiftly identifies trends & shifts in customer tastes
    - performs Market Basket Analysis (MBA)

      * analyzes Point-of-Sale or -Service (POS) data →
      * identifies relationships among
        products and/or services purchased

      - E.g. A customer who buys Brand X slacks
        has a 35% chance of buying Brand Y shirts.

  * *Agent* tool is also used by other Fortune 1000 firms

    - average ROI > 300 %
    - average payback in 1 ~ 2 years

# Case Study of a Mining Agent: Finbot

- Finbot = a learning agent for investment management.

  — Prediction of financial markets

  * *Stock market* prediction
    through a hybrid method
    of case reasoning and induction

  * *Interest rate* forecasting
    through complex models
    and statistical analysis

  * *Business cycle* prognosis
    through inductive reasoning &
    evolutionary computation

  * *Foreign exhange rate* prediction
    through neural networks &
    multivariate models

Table 1. Description of original variables. The entire data set consisted of monthly observations from Jan. 1981 to Dec. 1992. The training data set ranged from Jan. 1981 to May 1989; and the test set from June 1989 to Dec. 1992.

| Korea | | US | |
|---|---|---|---|
| Variable Name | Description | Variable Name | Description |
| CBY | Corporate Bond Yield with 3 years' maturity | TBILL | Treasury Bill with 1 year maturity |
| M2 | Money Stock | M2 | Money Stock |
| CPI | Consumer Price Index | CPI | Consumer Price Index |
| IPI | Industrial Production Index | IPI | Industrial Production Index |
| BCP | Permits for building construction | HS | Housing Starts |
| KOSPI | Korean Stock Price Index | SPX | Standard & Poors 500 |

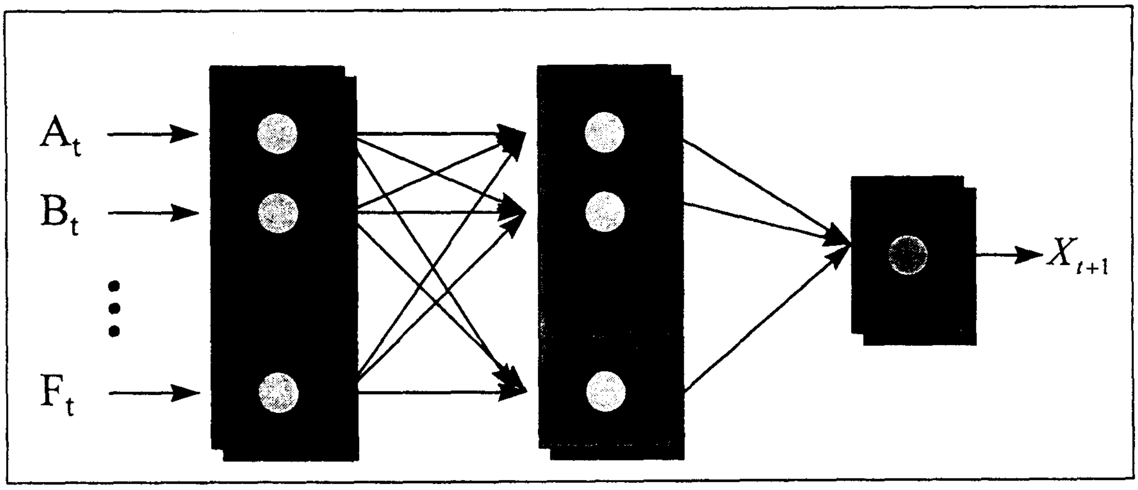



Figure 1. General architecture of the neural network (NN) models.

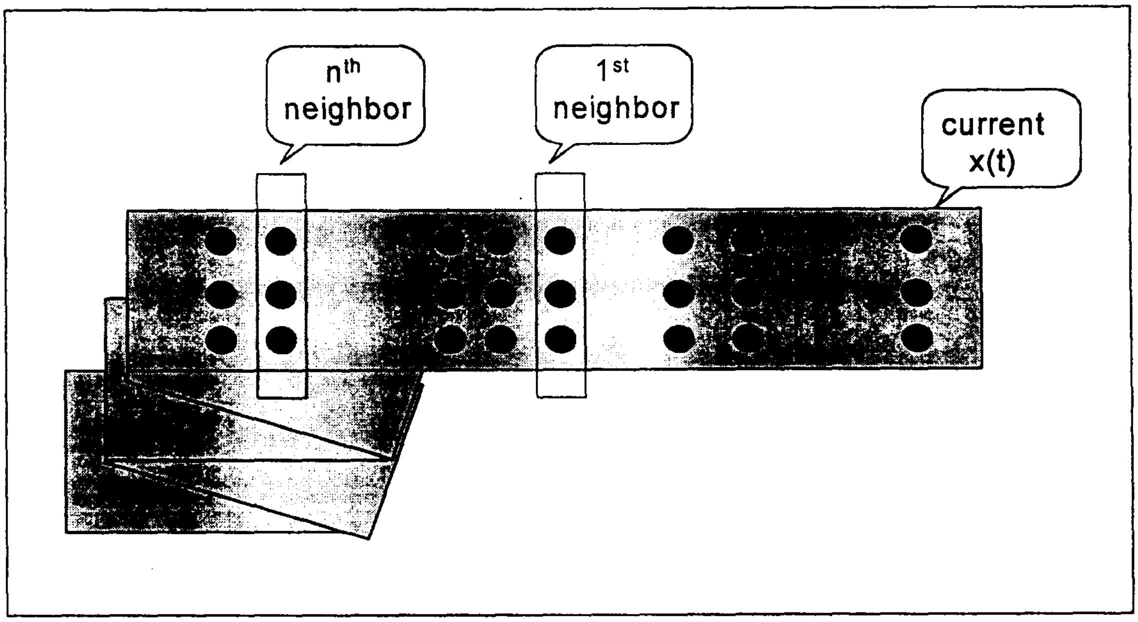



Figure 2. General architecture for case based reasoning (CBR).

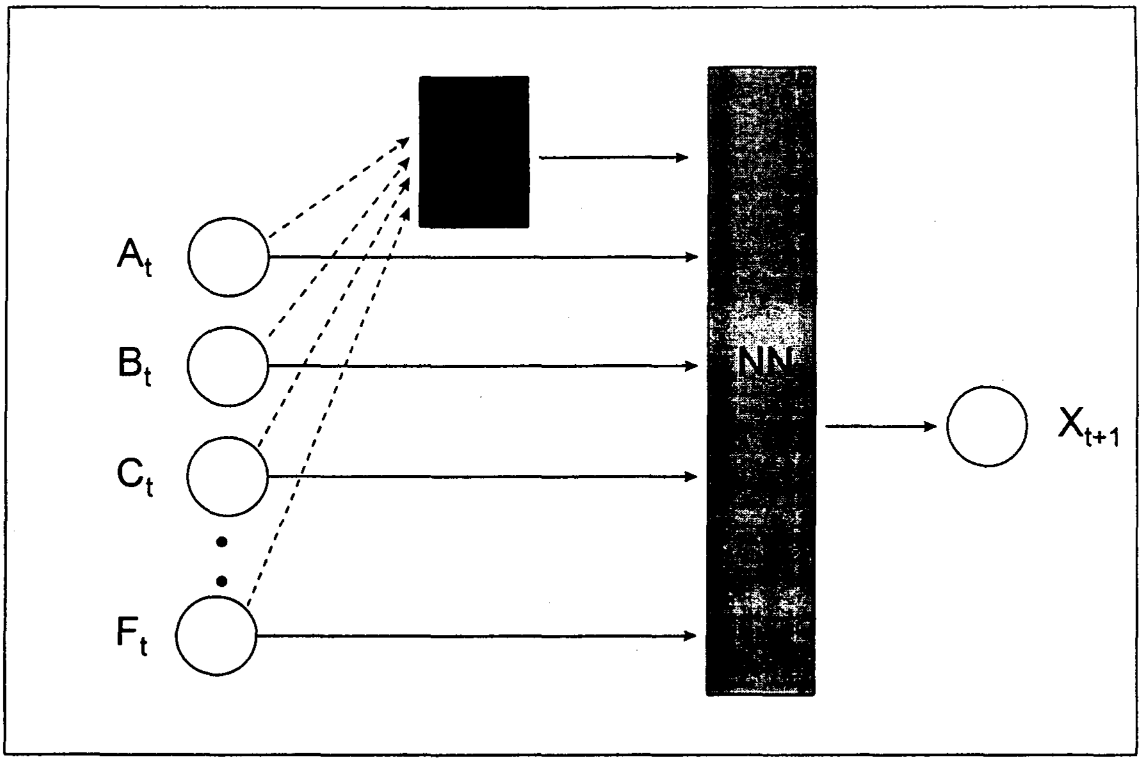



Figure 3. Architecture for the integrated methodology.

Table 2. List of models, their associated variables, and performance results in the case of Korean interest rate prediction. The following abbreviations are used: "NN" for the neural network model, "CBR" for the case based reasoning model, and "CBR+NN" for the integrated model. A set of t-tests were conducted for each pair of models according to each metric (APE, absolute deviation, and hit rate); no differences were statistically significant.

| Model | Input Variables | MAPE (%) | RMSE | Hit Rate (%) |
|---|---|---|---|---|
| NN_NOW | CBY[0], M2[0], CPI[0], IPI[0], BCP[0], KOSPI[0] | 2.478 | 0.541 | **62** |
| NN_STEP | BCP[0], BCP[4], CBY[0], CBY[6] KOSPI[4], KOSPI[5] M2[3], M2[5], M2[6] | 2.799 | 0.624 | 52 |
| CBR | CBY[0], M2[0], CPI[0], IPI[0], BCP[0], KOSPI[0] | **2.413** | **0.524** | 59 |
| CBR + NN | CBY[0], M2[0], CPI[0], IPI[0], BCP[0], KOSPI[0] + predicted value from CBR | 2.550 | 0.546 | 50 |
| Random | forecast $(X_{t+1}) = X_t$ | 2.510 | 0.550 | 53 |

Table 3. List of models, their associated variables, and performance results in the case of US interest rate prediction. The following abbreviations are used: "NN" for the neural network model, "CBR" for the case based reasoning model, and "CBR+NN" for the integrated model .

| Model | Input Variables | MAPE (%) | RMSE | Hit Rate (%) |
|---|---|---|---|---|
| NN_NOW | TBILL[0], M2[0], CPI[0], IPI[0], HS[0], SPX[0] | 3.366 | 0.216 | 74 |
| NN_STEP | CPI[1], HS[0], HS[3], IPI[2], TBILL[0], TBILL[5] | 3.745 | 0.247 | 63 |
| CBR | TBILL[0], M2[0], CPI[0], IPI[0], HS[0], SPX[0] | 3.455 | 0.231 | **81** |
| CBR + NN | TBILL[0], M2[0], CPI[0], IPI[0], HS[0], SPX[0] + predicted value from CBR | **3.166** | **0.208** | 74 |
| Random | forecast $(X_{t+1}) = X_t$ | 4.022 | 0.250 | 50 |

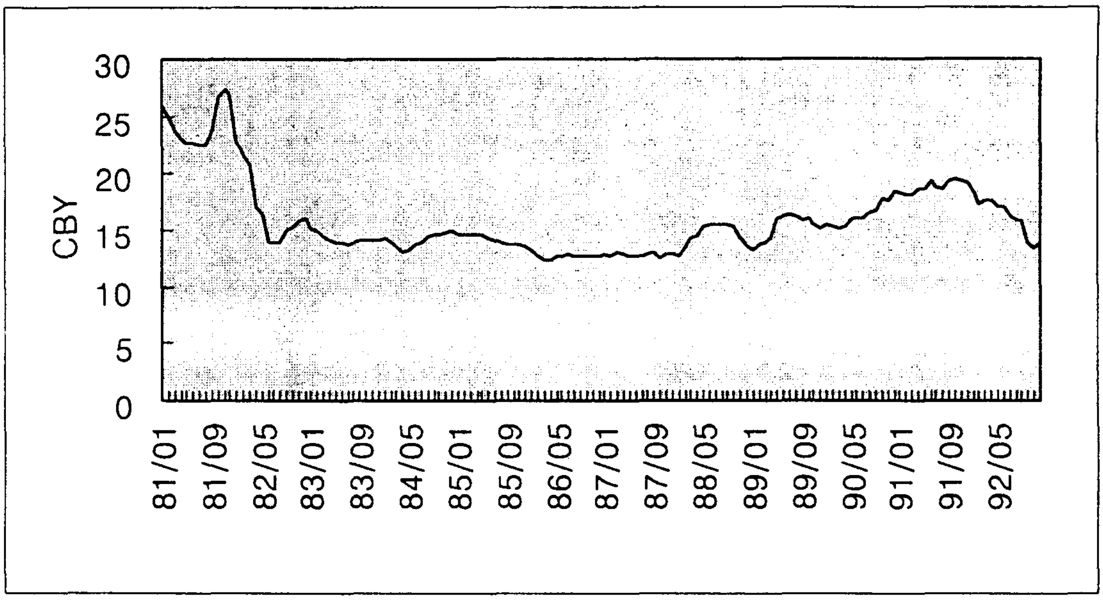



Figure 4-a. Korean corporate bond yield (CBY) with 3 years' maturity.

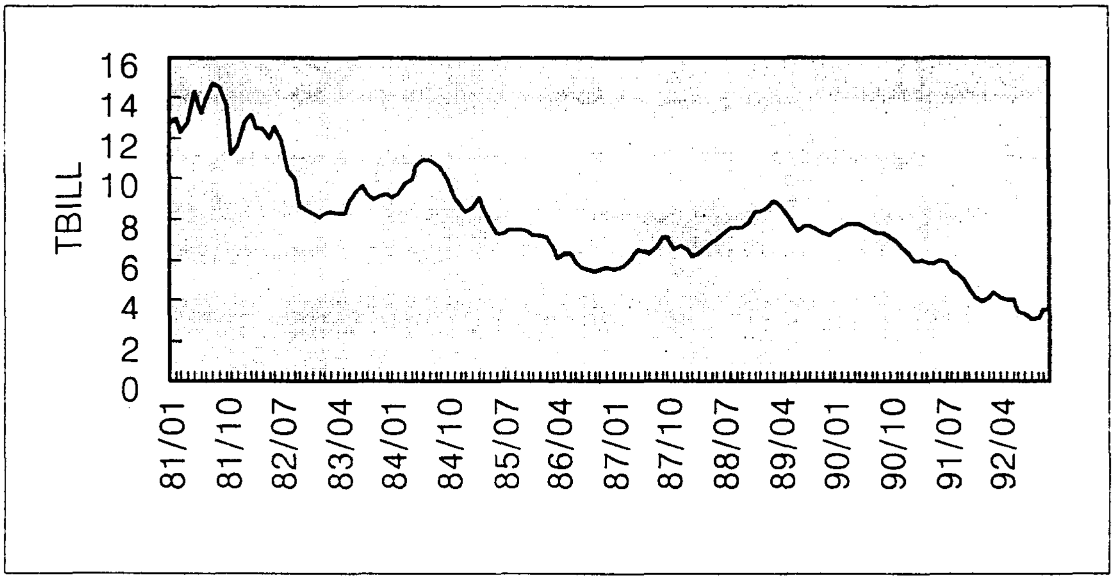



Figure 4-b. Yield (TBILL) of US Treasury bills with a maturity of 1 year.

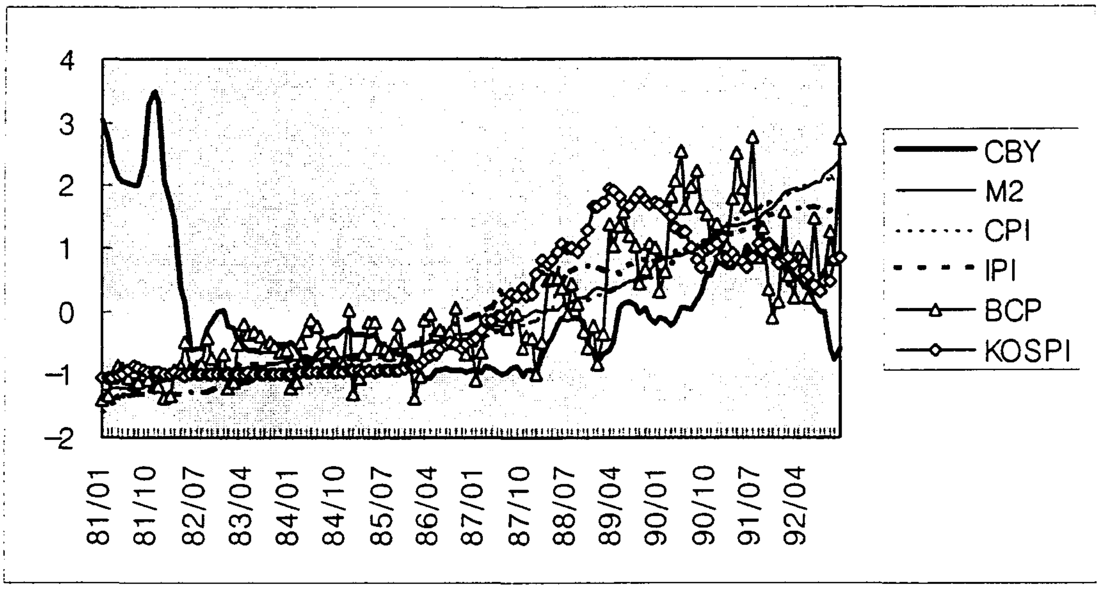



Figure 5-a. CBY and other macroeconomic variables for Korea (standardized values).

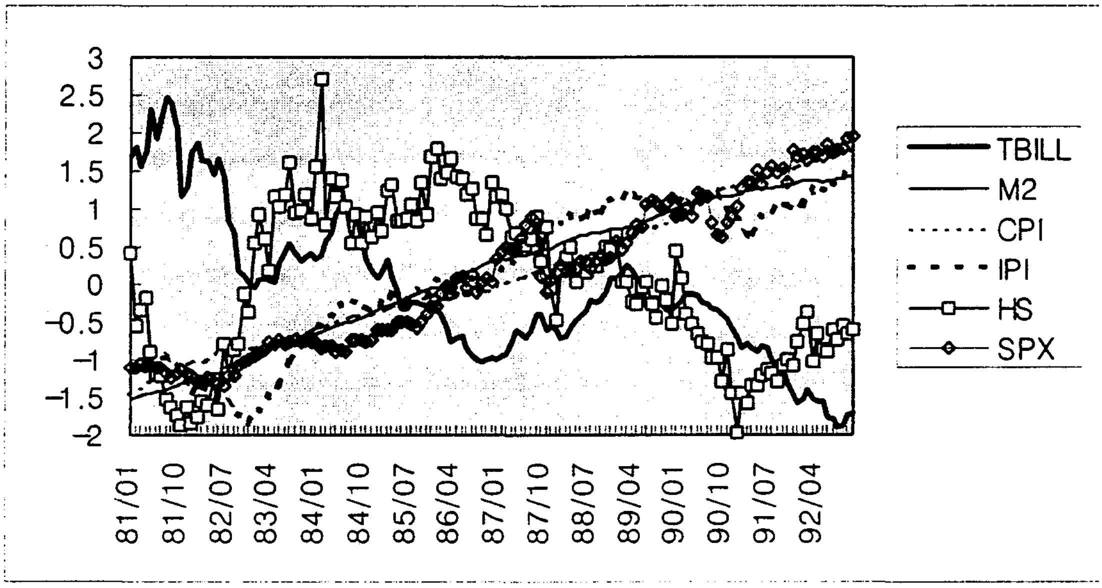



Figure 5-b. T-bill and other macroeconomic variables for US (standardized values).

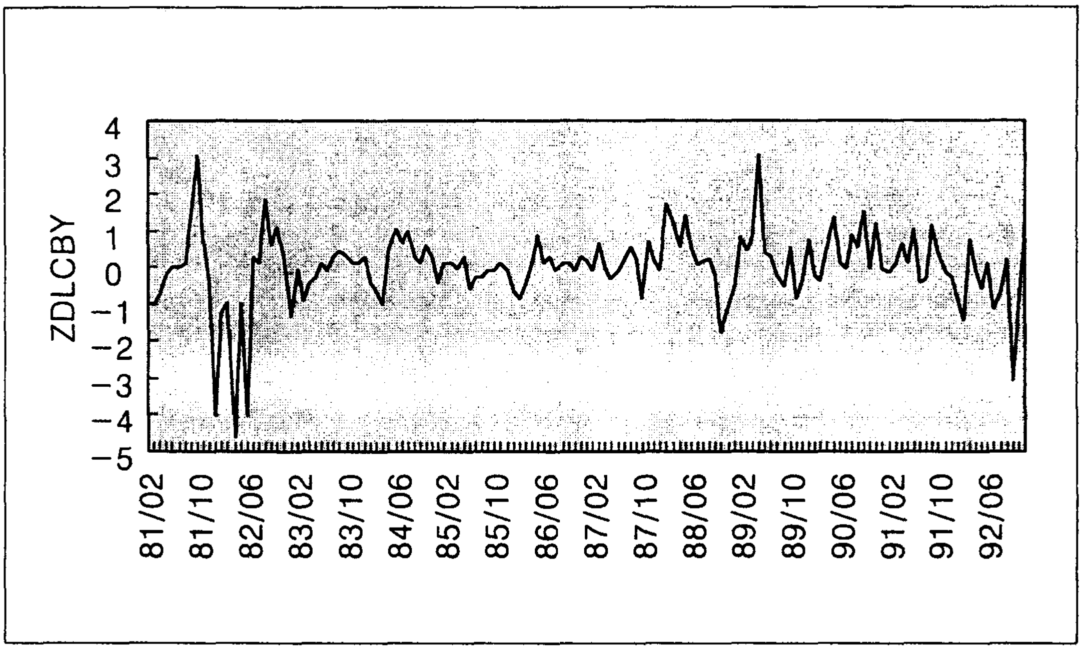



Figure 6-a. Plot of the differenced and standardized values of the log of Korean corporate bond yield with 3 years' maturity (ZDLCBY).

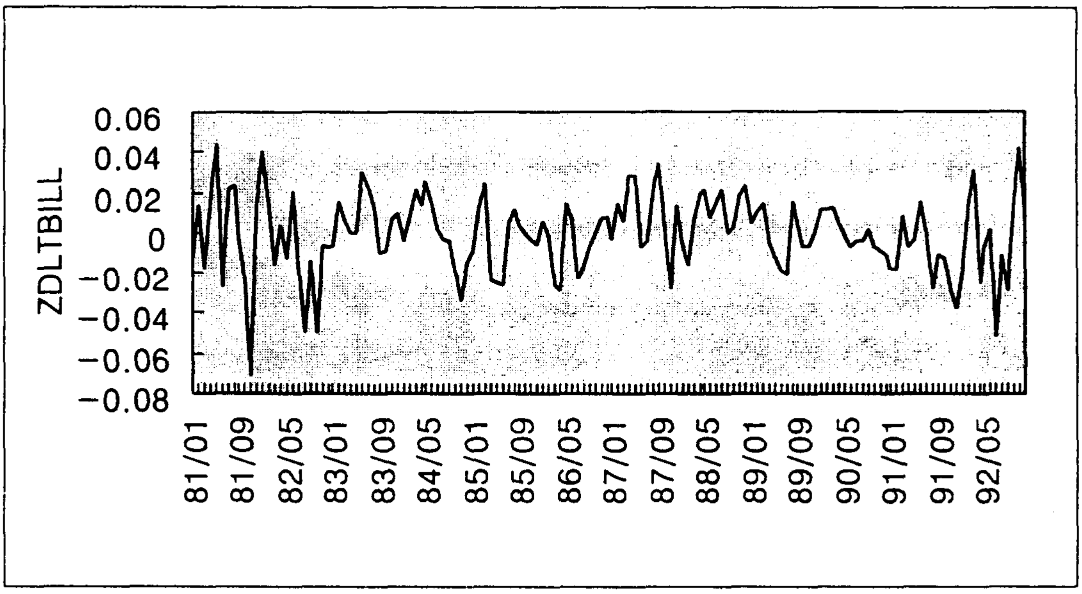



Figure 6-b. Plot of the differenced and standardized values of the log of US Treasury bill with 1 year's maturity (ZDLTBILL).

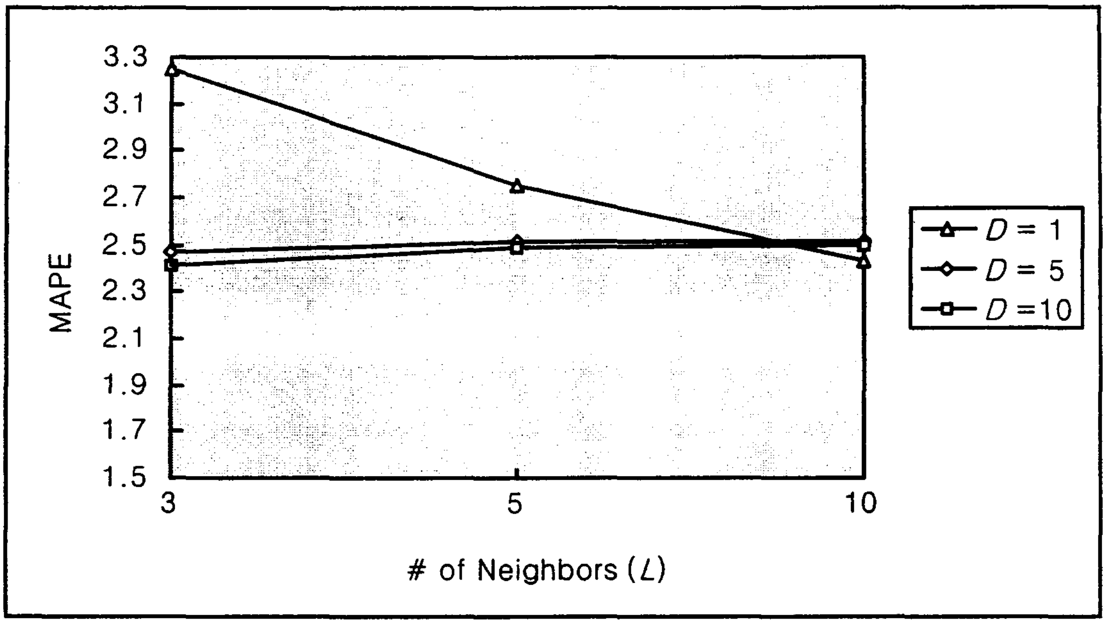



Figure 7-a. MAPE of residuals using CBR as a function of the number $L$ of neighbors ($L$ = 3, 5, 10) and size $D$ of the input vector ($D$ = 1, 5, 10) in predicting the Korean interest rate. The best model has parameters $L = 3$ and $D = 10$.

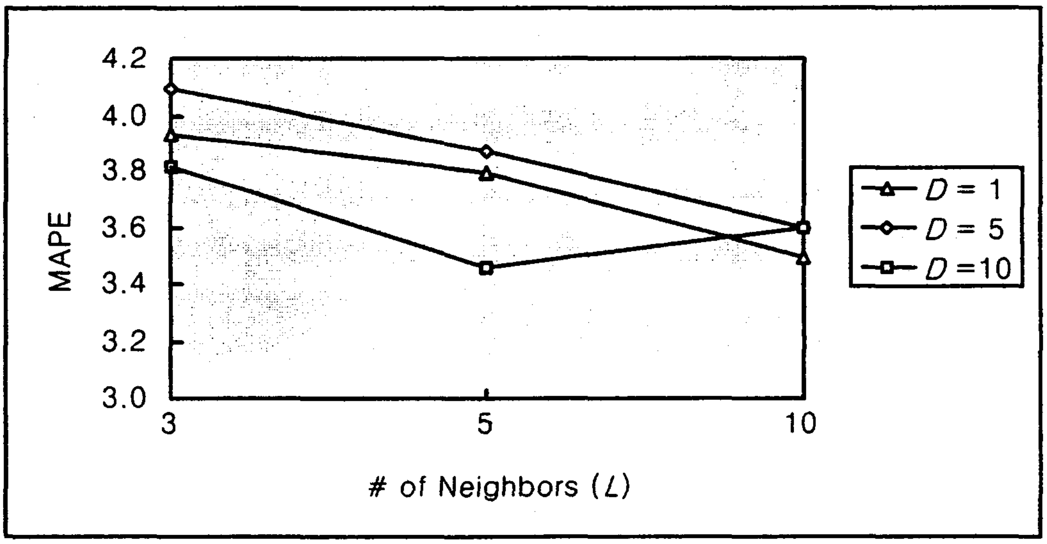



Figure 7-b. MAPE of residuals using CBR as a function of the number $L$ of neighbors ($L$ = 3, 5, 10) and size $D$ of the input vector ($D$ = 1, 5, 10) in predicting the US interest rate. The best model has parameters $L = 5$ and $D = 10$.

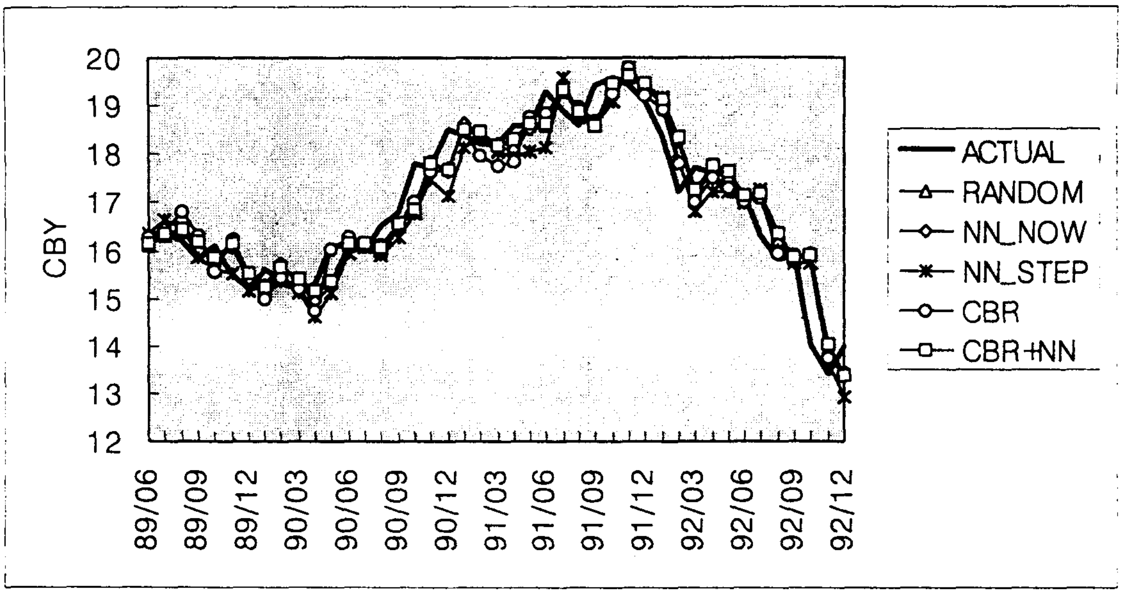



Figure 8-a. Actual vs. predicted values due to various models for the Korean interest rate, CBY.

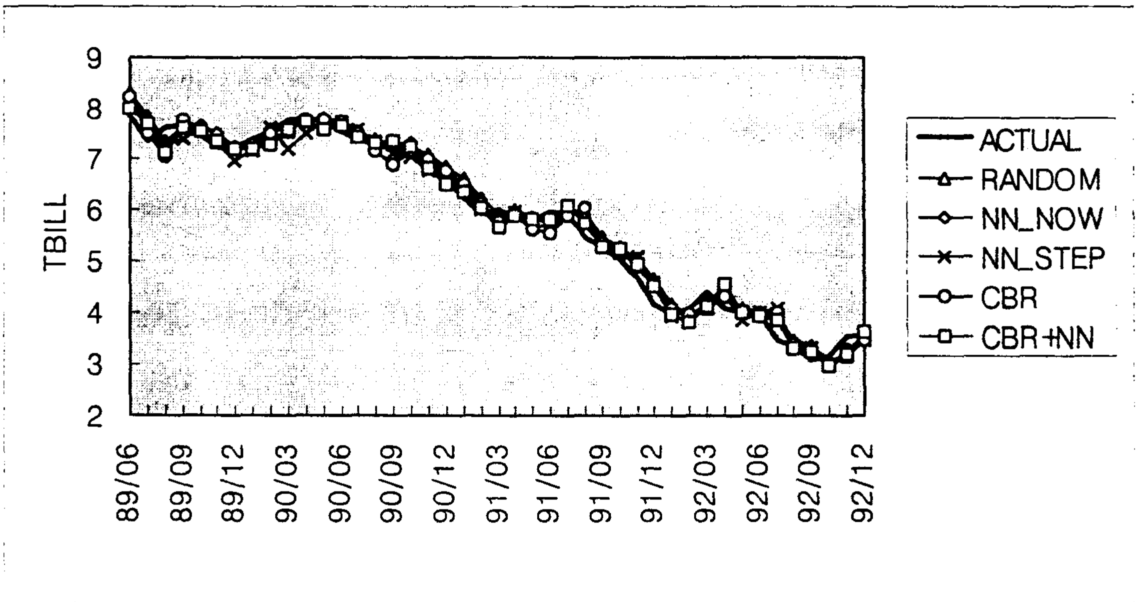



Figure 8-b. Actual vs. predicted values due to various models for the US interest rate, TBILL.

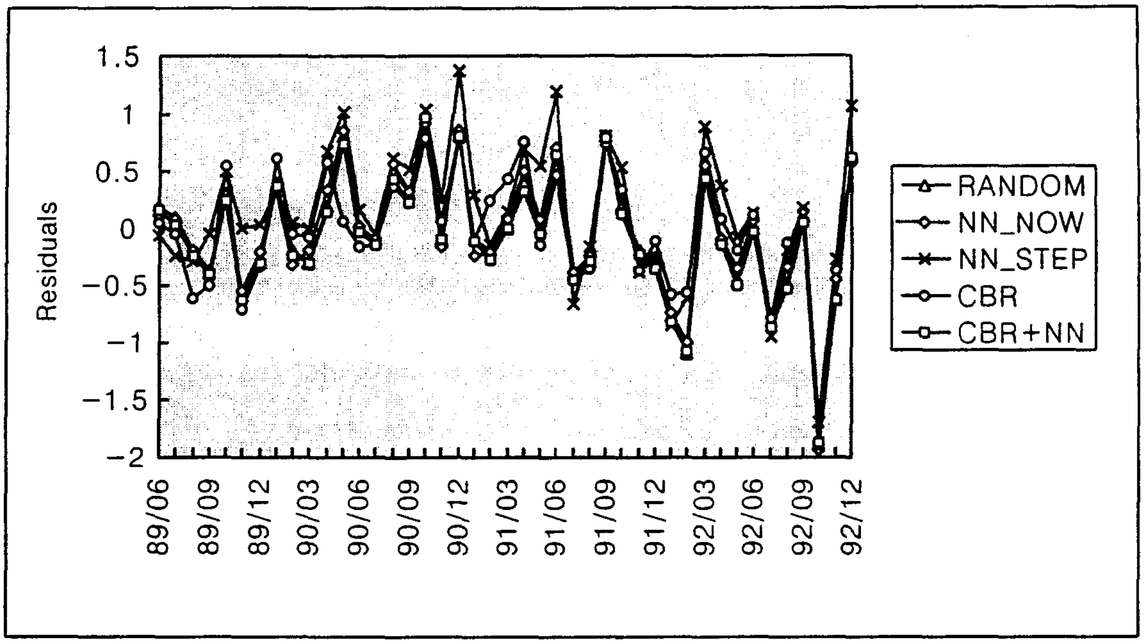



Figure 9-a. Plot of residuals from Figure 8-a for predicting Korean CBY.

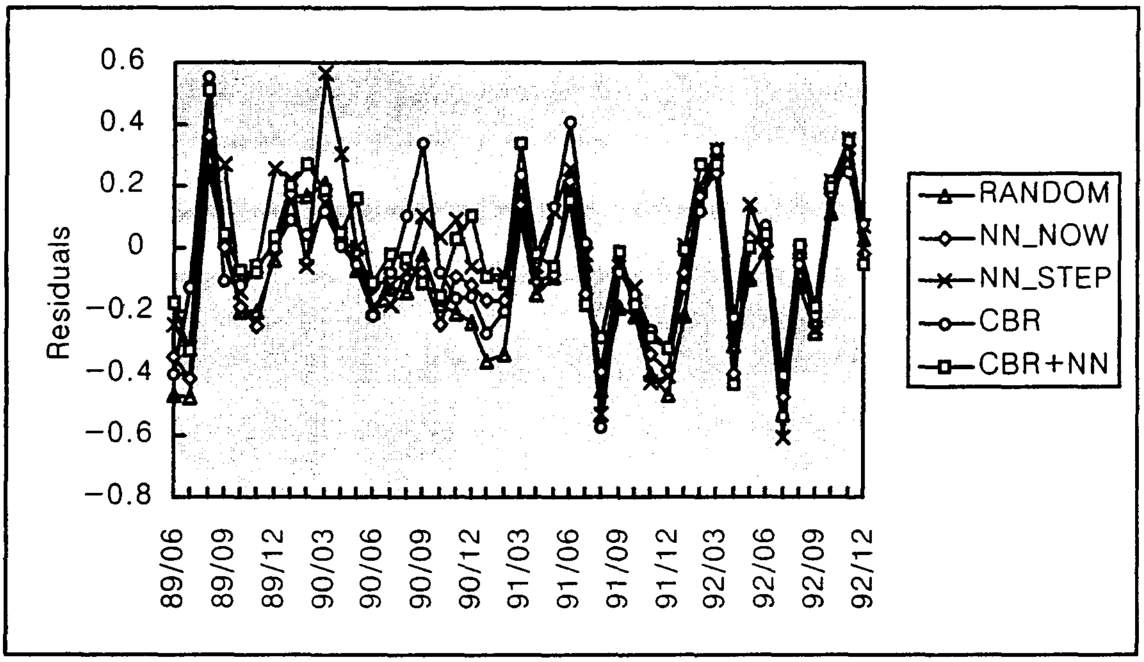



Figure 9-b. Plot of residuals from Figure 8-b for forecasting the US T-bill rate.

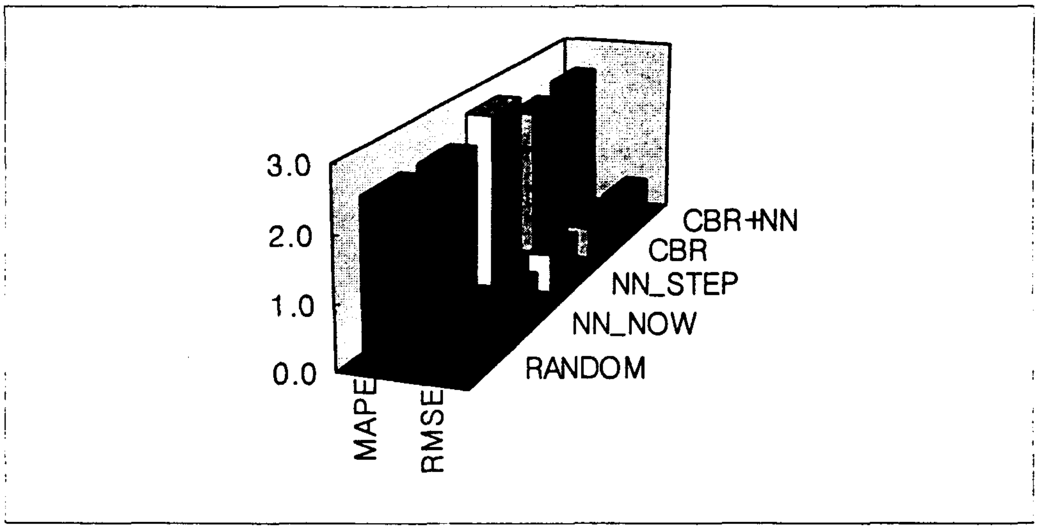



Figure 10-a. Plot of MAPE and RMSE resulting from forecasts of the Korean CBY.

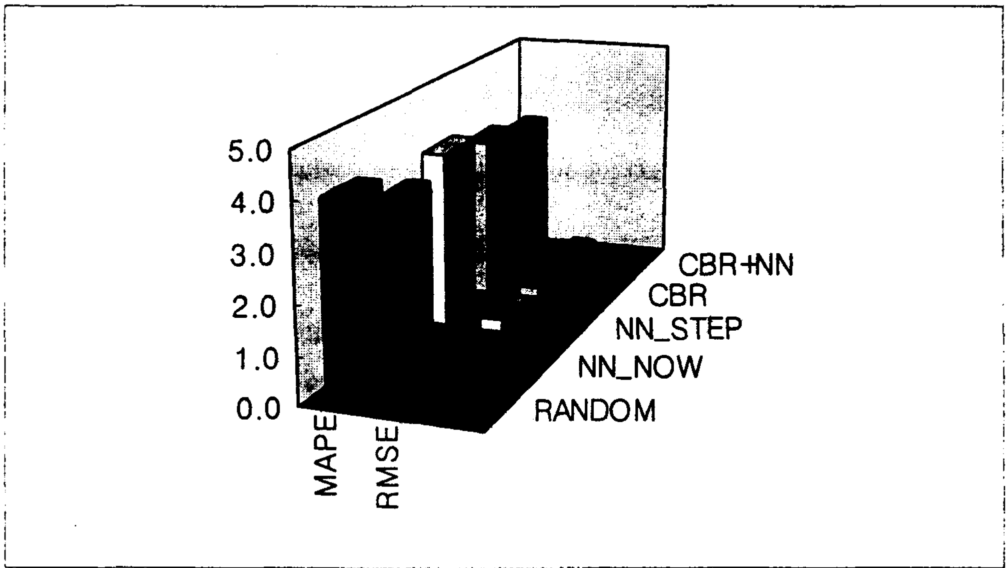



Figure 10-b. Plot of MAPE and RMSE resulting from forecasts of the US T-bill rate.

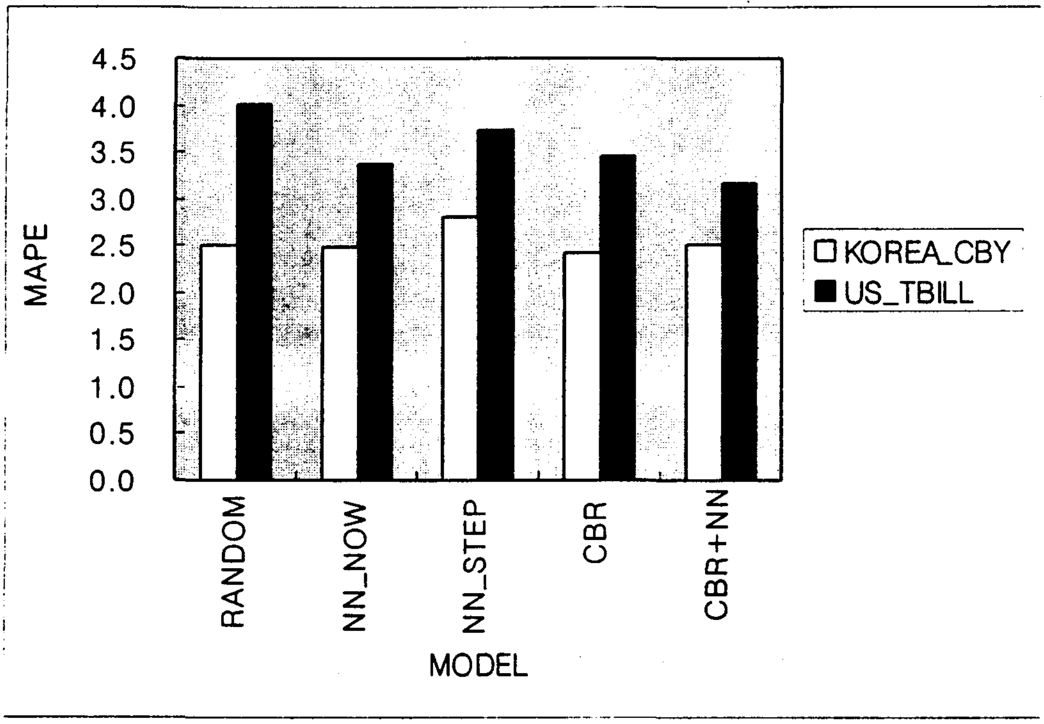



Figure 11. Plot of MAPE resulting from forecasts of Korean CBY and US TBILL. Each model exhibits a lower MAPE for Korea.

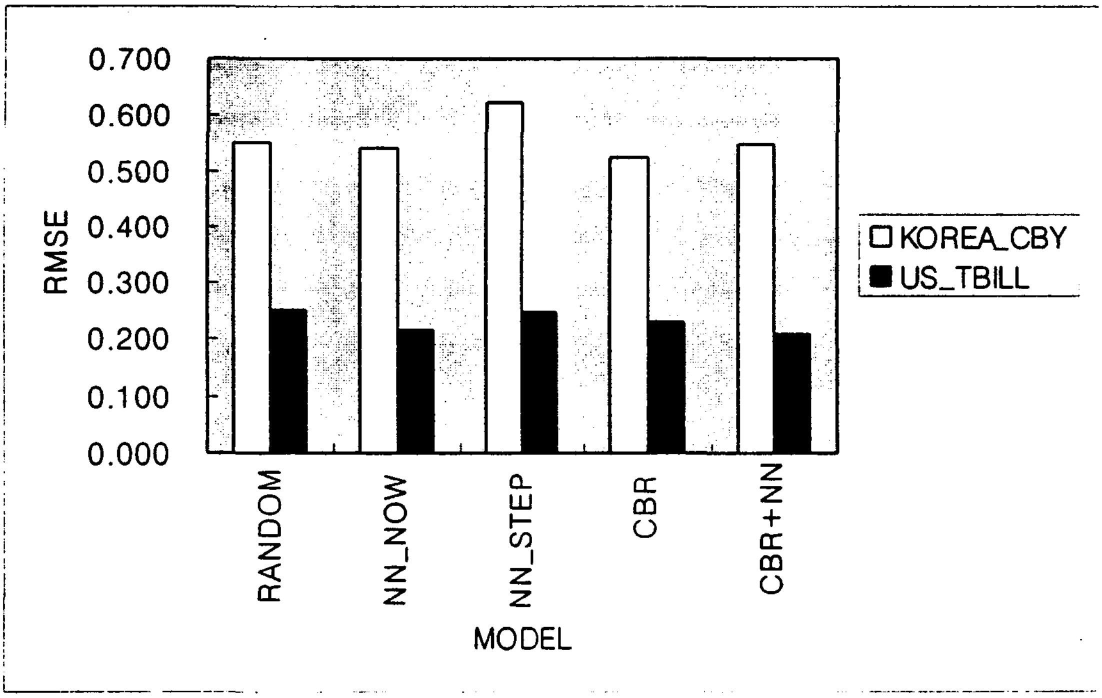



Figure 12. Plot of RMSE resulting from forecasting Korean CBY and US TBILL. Each model displays a higher RMSE for Korea.

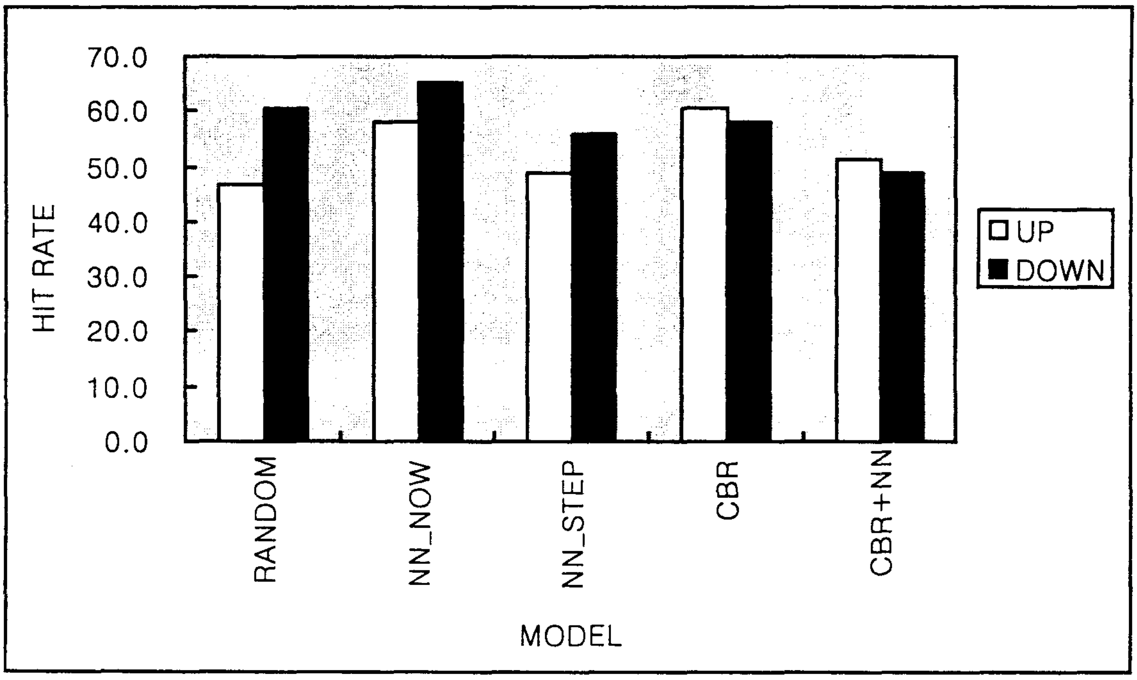



Figure 13-a. Histogram of hit rates resulting from forecasting Korean CBY. UP refers to a default call of an increase; that is, $X_{t+1} \geq X_t$ is classified as an increase. A DOWN perspective regards $X_{t+1} \leq X_t$ as a decrease.

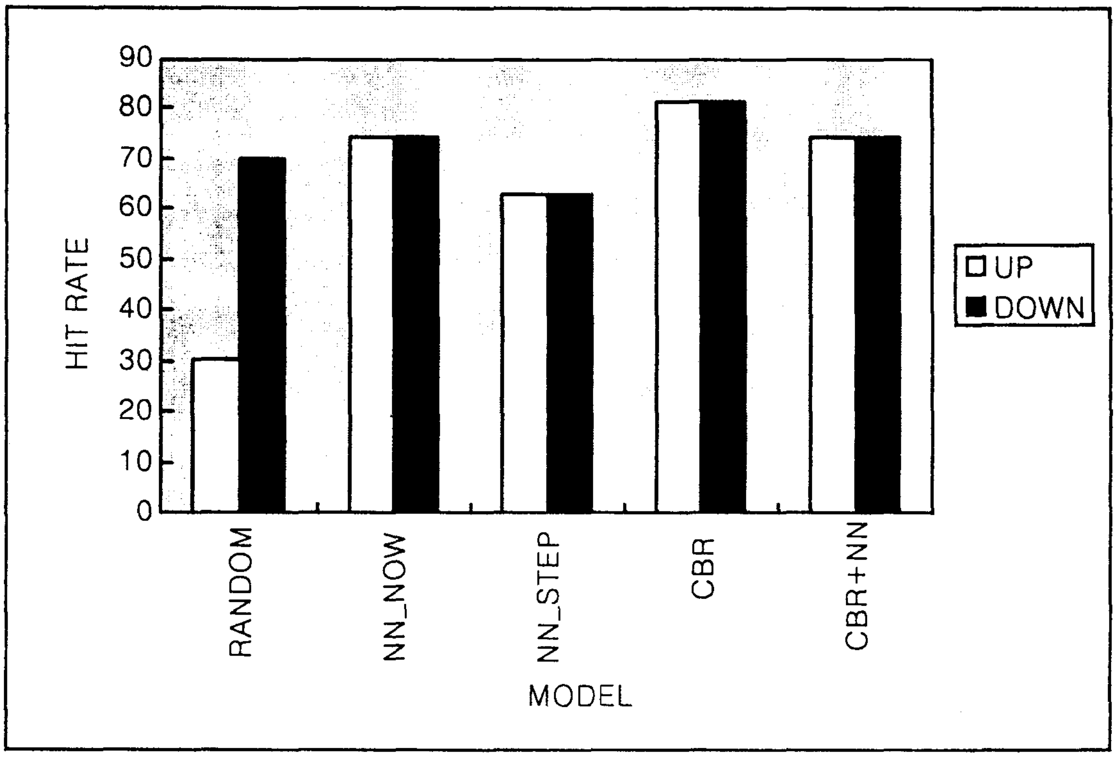



Figure 13-b. Plot of hit rate resulting from forecasts of US TBILL.

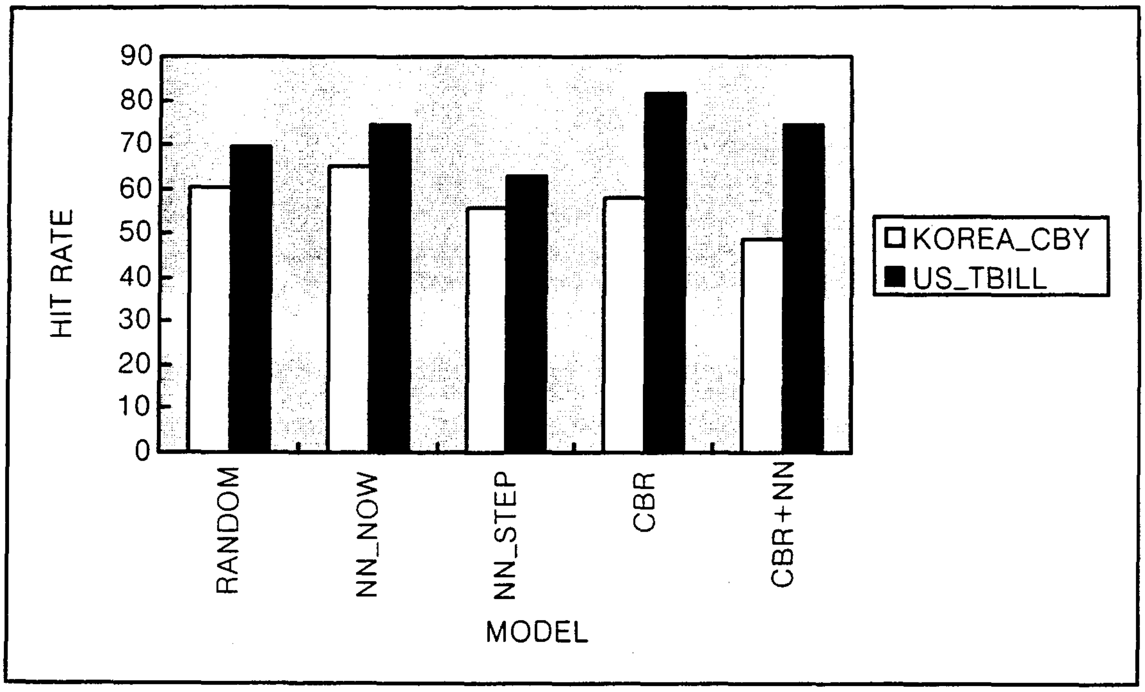



Figure 13-c. Plot of hit rate (average of UP and DOWN default perspectives) resulting from forecasting Korean CBY and US TBILL.

Table 4. Chi-square tests for the hit rate.

| COUNTRY | Chi-square value | Critical value ( $\alpha$ =0.05) | Decision |
|---|---|---|---|
| Korea_CBY | 1.677 | 9.488 | Accept $H_0$ |
| US_T-Bill | 12.201 | | Reject $H_0$ |

Table 5. Pairwise t-tests for the differences in residuals for US interest rate prediction. The upper right triangle tabulates the t-tests based on the absolute percentage errors (APE) of residuals, with the significance level in parentheses. The lower left triangle lists the t-tests based on the absolute values of the deviations (AD).

| | NN_NOW | NN_STEP | CBR | CBR + NN | RANDOM |
|---|---|---|---|---|---|
| NN_NOW | | -1.33 (0.190) | -0.32 (0.747) | 0.91 (0.367) | **-3.17 (0.003)** |
| NN_STEP | 1.17 (0.250) | | 0.91 (0.371) | **1.73 (0.091)** | -0.82 (0.414) |
| CBR | 0.35 (0.725) | -0.75 (0.459) | | 0.88 (0.386) | **-1.83 (0.074)** |
| CBR + NN | -0.80 (0.430) | -1.61 (0.115) | -0.89 (0.380) | | **-2.41 (0.020)** |
| RANDOM | **3.25 (0.002)** | 0.70 (0.485) | 1.61 (0.115) | **2.37 (0.023)** | |

Table 6. Pairwise test for proportions using the metric of hit rate in predicting US interest rates. The first entry in each cell presents the z-value while the significance level is shown in parentheses.

| | NN_STEP | CBR | CBR + NN | RANDOM |
|---|---|---|---|---|
| NN_NOW | 1.16<br>(0.246) | -0.78<br>(0.435) | 0.00<br>(1) | **2.34**<br>**(0.019)** |
| NN_STEP | | **-1.92**<br>**(0.055)** | -1.16<br>(0.246) | 1.20<br>(0.230) |
| CBR | | | 0.78<br>(0.435) | **3.07**<br>**(0.002)** |
| CBR + NN | | | | **2.34**<br>**(0.019)** |

Table 7-a. Types of error by model for Korean CBY. Type I (false rejection) refers to a down prediction when the actual index rises; and Type II (false acceptance) refers to an up prediction when the market falls. Each entry denotes the proportion of mistakes over the test period.

| | Type I | Type II |
|---|---|---|
| NN_NOW | 0.2791 | 0.1395 |
| NN_STEP | 0.3953 | 0.1163 |
| CBR | 0.1860 | 0.2093 |
| CBR + NN | 0.0698 | 0.4186 |

Table 7-b. Types of error by model for the US TBILL. Type I (false rejection) refers to a down prediction when the actual index rises; and Type II (false acceptance) refers to an up prediction when the market falls. Each entry denotes the proportion of mistakes over the test period.

| | Type I | Type II |
|---|---|---|
| NN_NOW | 0.1395 | 0.1163 |
| NN_STEP | 0.2791 | 0.0930 |
| CBR | 0.1163 | 0.0698 |
| CBR + NN | 0.1860 | 0.0698 |

| Source of Variation | Sum of Squares | DF | Mean Square | F | Sig of F |
|---|---|---|---|---|---|
| Main Effects | .012 | 5 | .002 | 2.952 | .012 |
| MODEL | .001 | 4 | .000 | .425 | .791 |
| COUNTRY | .011 | 1 | .011 | 13.061 | .000 |
| 2-Way Interactions | .001 | 4 | .000 | .278 | .892 |
| Explained | .013 | 9 | .001 | 1.764 | .073 |
| Residual | .346 | 420 | .001 | | |
| Total | .359 | 429 | .001 | | |

430 cases were processed.

Figure 14. Two-way ANOVA based on absolute percentage error (APE).

| Source of Variation | Sum of Squares | DF | Mean Square | F | Sig of F |
|---|---|---|---|---|---|
| Main Effects | 6.269 | 5 | 1.254 | 16.128 | .000 |
| MODEL | .134 | 4 | .034 | .431 | .786 |
| COUNTRY | 6.134 | 1 | 6.134 | 78.915 | .000 |
| 2-Way Interactions | .068 | 4 | .017 | .218 | .928 |
| Explained | 6.336 | 9 | .704 | 9.057 | .000 |
| Residual | 32.649 | 420 | .078 | | |
| Total | 38.985 | 429 | .091 | | |

430 cases were processed.

Figure 15. Two-way ANOVA based on absolute deviation (AD). The term "absolute deviation" is used as a matter of convention, although "error" or "residual" would serve as well.

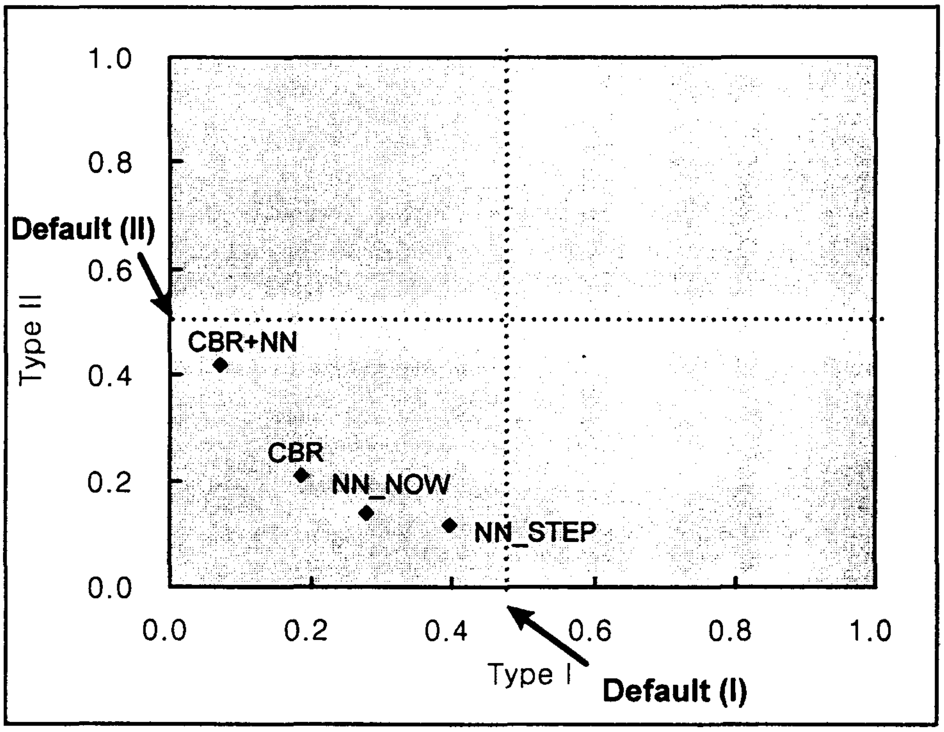



Figure 16-a. Mistake chart for the prediction of Korean CBY. Dashed lines indicates default mistakes based on a constant prediction of "Down" or "Up". For instance, Default (I) is the expected Type I error due to a constant forecast of "Down". Since all models lie in the southwest region, they outperform the default predictions.

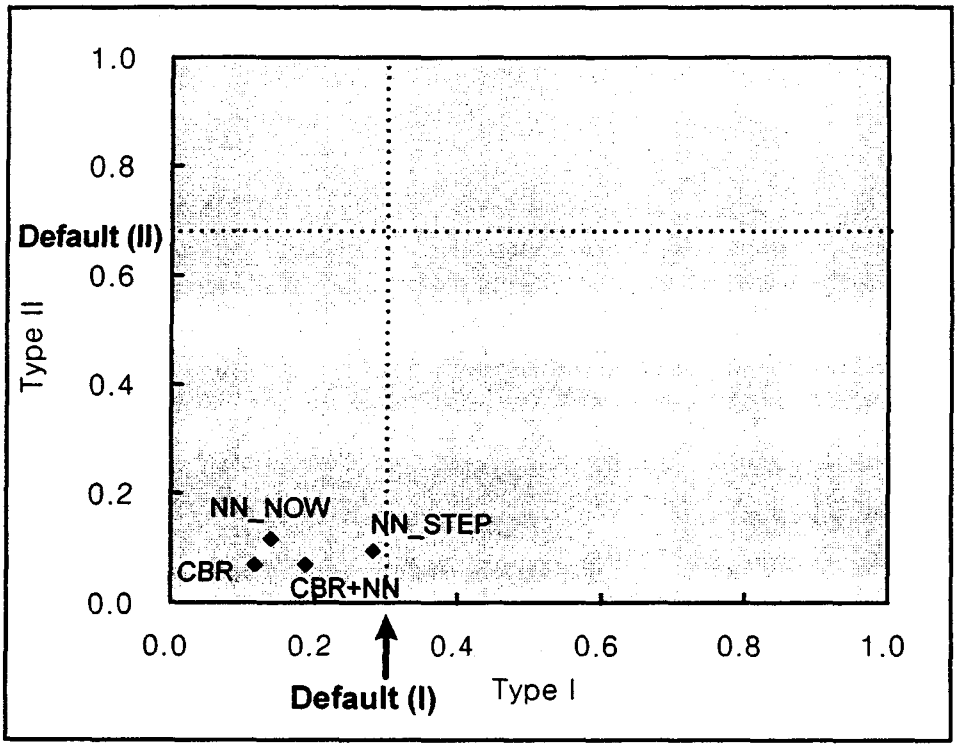



Figure 16-b. Mistake chart for predicting the US T-bill rate.

## Information Sector in 2000AD