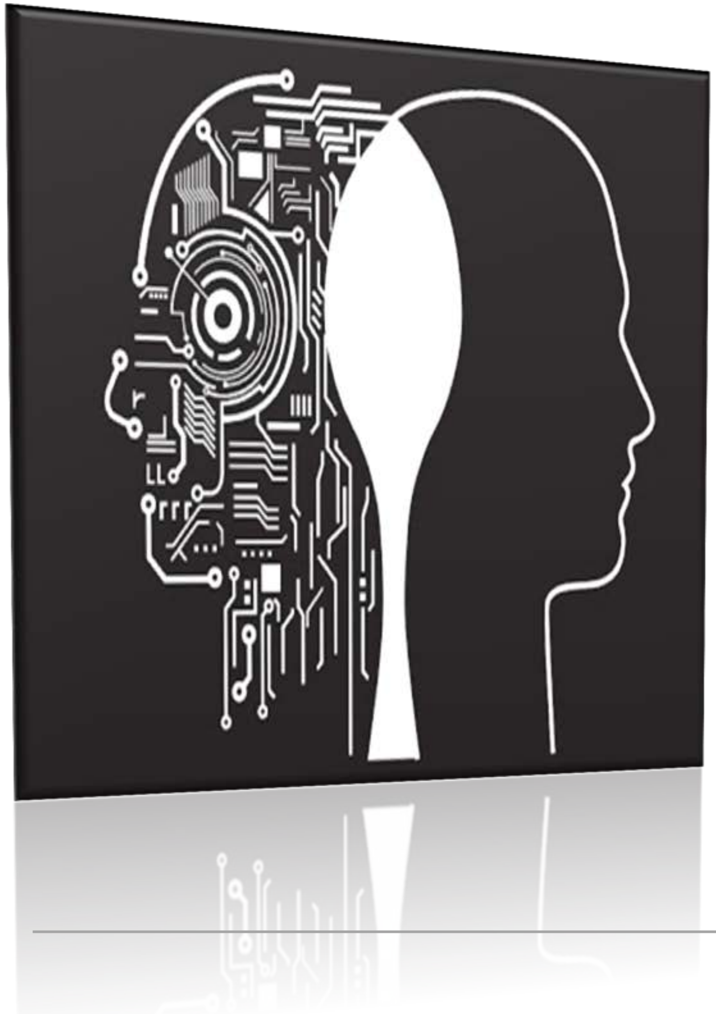


Developing intelligent tutoring support for forecasting

The Forecasting Intelligent Tutoring System

Dr. Devon K. Barrow
School of Strategy and Leadership, Coventry University

Modern education: challenges

- Facilitating large classrooms
- Designing assessment and marking
- Providing individually tailored feedback
- Encouraging participation
- Developing resources: nature, type and quantity

"I have too much homework to mark. It becomes almost impossible to give effective feedback for everyone."
Anonymous

Current landscape of business forecast education

- Expensive specialist forecasting training courses [1,2]
- Self taught using text books and/or a combination of ad hoc web-based content and online tutorials
- Short online courses
- A handful of universities provide a module on business forecasting at the Undergraduate and Masters level
- A handful of universities provide modules on business forecasting at the Undergraduate and Masters level
- *Forecasting and decision support systems*

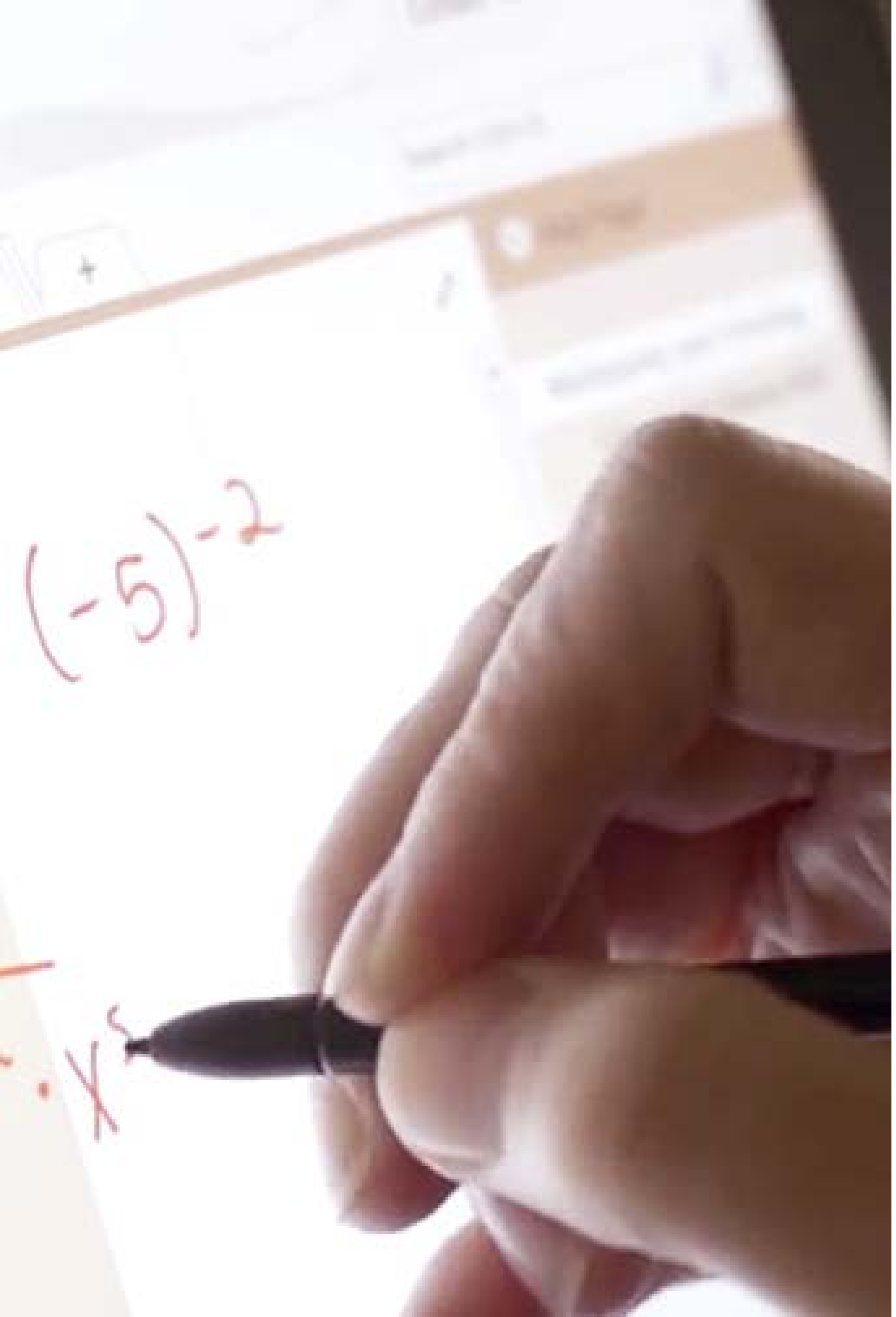
[1] CPDF In Demand Forecasting [Online] Available at: http://cpdftraining.org/ (Accessed March 19, 2015)
[2] Lancaster Centre for Forecasting [Online] Available at http://www.lancaster.ac.uk/lums/forecasting/ (Accessed March 31, 2015)
[3] Lancaster University Management School [Online] Available at http://goo.gl/osS7qA (Accessed March 31, 2015)

Research objectives

1. Develop individualised tutoring support for the business forecasting curriculum
2. Understand how individuals/forecasters *learn* ‘key’ forecasting task

Developing ‘intelligent’ tutoring support

Immediate and customized training individually tailored to the user



Intelligent tutoring systems

- Educational software systems that use artificial intelligence techniques to adapt the instruction to the individual student.
- Immediate and customized training individually tailored to the user
- Improvements in learning (Gertner & VanLehn, 2000; Koedinger, Anderson, Hadley, Mark, & Others, 1997).
- Underpinning theories include:
  - Ohlsson's theory of learning from performance errors (Ohlsson, 1996)
  - Anderson's ACT theories of skill acquisition (Anderson, 1993).
- Learning from negative and positive feedback (Mitrovic, Ohlsson, & Barrow, 2013).

The Domain: time series decomposition

- A first step in creating forecasts and a prerequisite in all time series analysis.
- Allows an understanding of the underlying components present in the time series.

Classical time series decomposition:

- The additive model: assumes that seasonal variation is relatively constant over time is as follows: $y_t = S_t + T_t + E_t$
- The multiplicative model: assumes that seasonal variation increases over time is given as follows: $y_t = S_t \times T_t \times E_t$

Conceptual design informed by:

Research Literature

Forecasting
Education and learning
Human computer interaction
Psychology
…

Experts

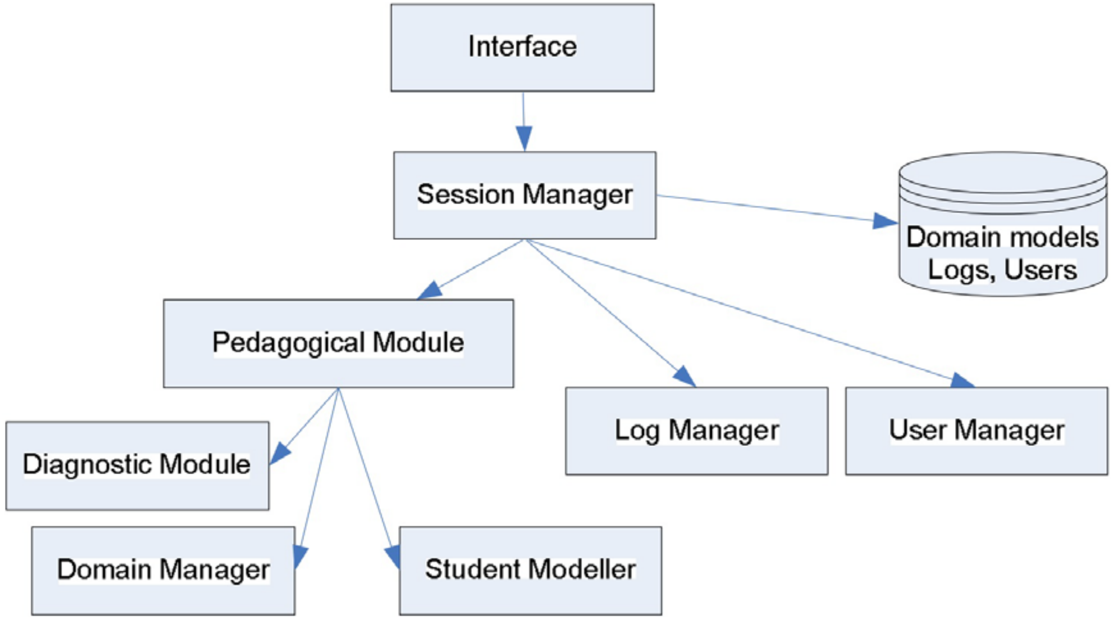
Forecasting
Pedagogical design
Intelligent Tutoring Systems
Protocol analysis
…

Think-aloud Protocols

The ‘student voice’

Conceptual design: literature

- Feedback
  - Keep records of forecasts and use them appropriately to obtain feedback. Reduce forecasters reliance on memory of previous performance
  - ‘outcome feedback’ e.g. related to the accuracy (Harvey 2001)
  - Immediate (Bolger and Wright 1994; Fischer and Harvey 1999)
- Presentation of data
  - Present data in graphical form
  - Forecasts of trended series presented graphically are much less biased than forecasts presented in tabular form (Harvey and Bolger 1996).
- Data availability
  - Increases event recall
  - A positive correlation between availability and speed and confidence in task execution (Goldstein and Gigerenzer 1999)



The FITS Architecture

FITS Architecture

1. Interface – controls interaction between student and tutor e.g. select/change domains/problems, submit solution for evaluation etc.

2. Student model – maintains a long-term model of the student's knowledge

3. Pedagogical module - decides how to respond to each student request.

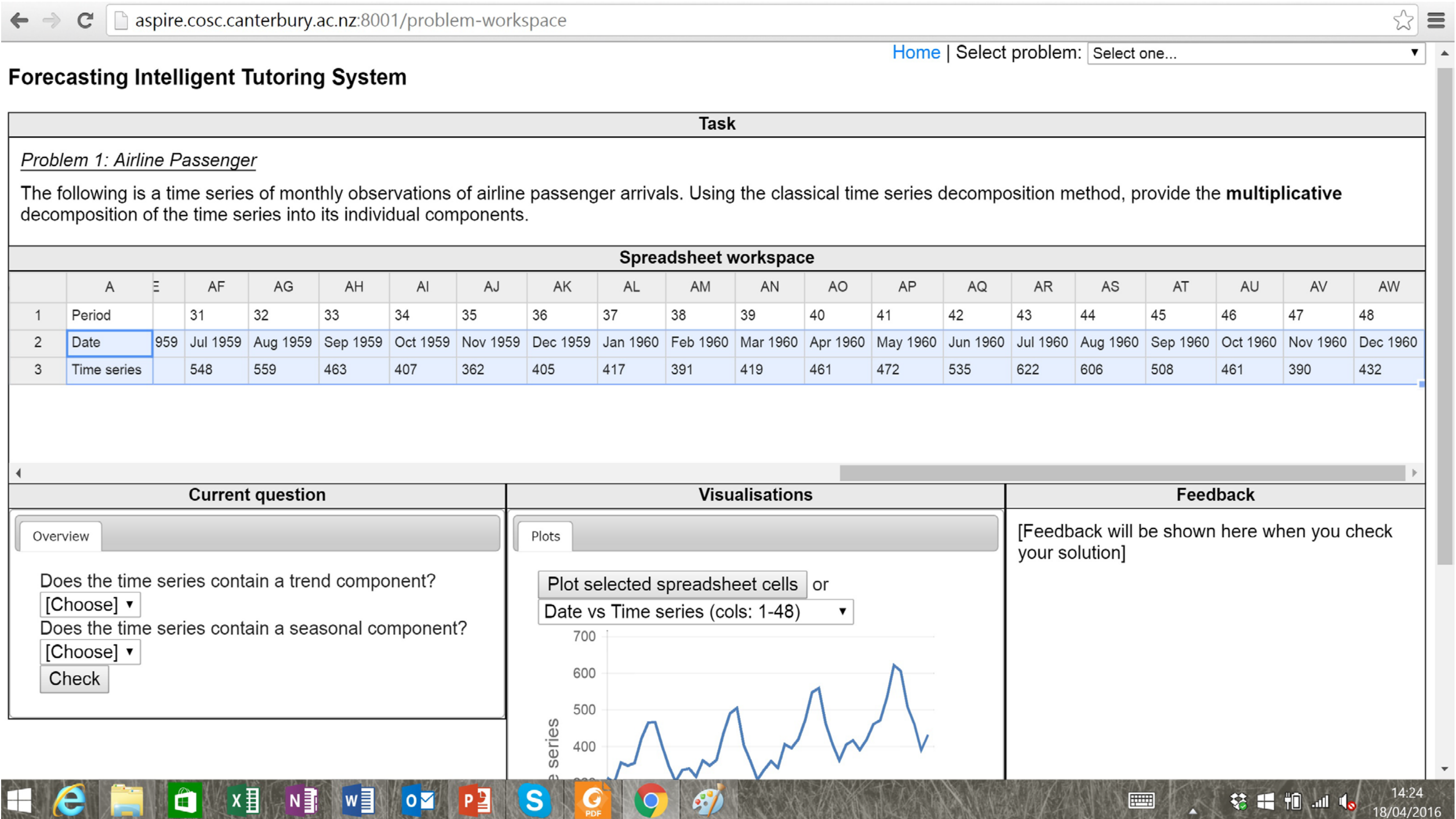
Knowledge representation

- “If <relevance condition> is true, then <satisfaction condition> had better also be true, otherwise something has gone wrong.

- Example of a syntax constraint:

```
(and (equalp (page-number *ss*) 1)
     (not (null (Trend *is*)))
     (not (null (Trend *ss*)))
     (component-available-p (Trend *ss*))
     (match '(?*d1 <i> ?id "Trend" ?p0 </i> ?*d2) (Trend *ss*) *bindings*))
(not (equalp "" ?p0))
```

Feedback Message: “You have forgotten to specify a value for the trend”


aspire.cosc.canterbury.ac.nz:8001/problem-workspace
Home | Select problem: Select one...
Forecasting Intelligent Tutoring System
Task
Problem 1: Airline Passenger
The following is a time series of monthly observations of airline passenger arrivals. Using the classical time series decomposition method, provide the multiplicative decomposition of the time series into its individual components.
Spreadsheet workspace
A E AF AG AH AI AJ AK AL AM AN AO AP AQ AR AS AT AU AV AW
1 Period 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
2 Date 959 Jul 1959 Aug 1959 Sep 1959 Oct 1959 Nov 1959 Dec 1959 Jan 1960 Feb 1960 Mar 1960 Apr 1960 May 1960 Jun 1960 Jul 1960 Aug 1960 Sep 1960 Oct 1960 Nov 1960 Dec 1960
3 Time series 548 559 463 407 362 405 417 391 419 461 472 535 622 606 508 461 390 432
Current question
Overview
Does the time series contain a trend component?
[Choose]
Does the time series contain a seasonal component?
[Choose]
Check
Visualisations
Plots
Plot selected spreadsheet cells or
Date vs Time series (cols: 1-48)
700
600
500
400
e series
Feedback
[Feedback will be shown here when you check your solution]
14:24
18/04/2016

Pilot Study Evaluation

The "two-sigma problem" - students who receive one-on-one instruction perform two standard deviations better than students who receive traditional classroom instruction (Bloom 1984).

Pilot Study: Design

- Participants:
  - Masters level students enrolled on business forecasting module at Lancaster University (approx. 70).
  - Management Science, Accounting and Finance, Commuting and Communications
  - *Knowledge of decomposition: students had previously received a lecture and workshop on time series decomposition*

- Experiment Setup:
  - Week 1: Students do pre-test
  - Week 2-3: Students are able to use the system
  - Week 4: Students do post-test

Pilot Study: Results

- Pre-test:
  - 17 students
  - Avg. score of 4.41 out of 15
  - Min score 0
  - Max score 15
- Post-test
  - 9 students
  - Avg. score 7.11 out of 15
  - Min score 0
  - Max score 15

	Constraints Used	Solved Problems	Messages	Time (Mins)	Pre-test	Post-test
Participant 1	43	10	140	87.23333	9	15
Participant 2	38	1	26	15.95	3	15
Participant 3	43	10	144	110.38333	7	12
Participant 4	0	0	0	2.05	4	4

The team

- Developers
  - Prof. Tanja Mitrovic – University of Canterbury (middle)
  - Mr. Jay Holland – University of Canterbury (left)
  - Dr. Devon Barrow [Principle Investigator] – Coventry University (right)

- Contributors
  - Dr. Nikoloas Kourentzes – Lancaster University
  - Dr. Mohammad Ali [Co-investigator] – Coventry University

- Comments
  - Dr. Stephan Kolassa and Dr. Roland Martin

Lancaster University

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Coventry University

Questions?

Devon K. Barrow

School of Strategy and Leadership

Coventry University

Coventry, CV5 7HA, UK

Tel.: +44 024 7765 7743

Email: devon.barrow@coventry.ac.uk

This project is funded under the Coventry University pump-prime grant scheme

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