Introduction to Expert Systems

Concepts and Definitions of Artificial Intelligence

- **Knowledge-based systems (KBS)**

  Technologies that use qualitative *knowledge* rather than mathematical models to provide the needed supports.

Concepts and Definitions of Artificial Intelligence

- **Artificial intelligence (AI)**
  - The subfield of computer science concerned with symbolic reasoning and non-algorithmic methods of problem solving
  - How to make computers do things at which people are better
- **Turing test**
  - A test designed to measure the “intelligence” of a computer
  - A human interviewer cannot identify the computer or human while interacting with both unseen human and an unseen computer

Concepts and Definitions of Artificial Intelligence

- Characteristics of artificial intelligence
  - Symbolic processing
    - Solve problems by manipulating symbols
  - **Heuristics**
    - Informal, judgmental knowledge of an application area that constitutes the “rules of good judgment” in the field.

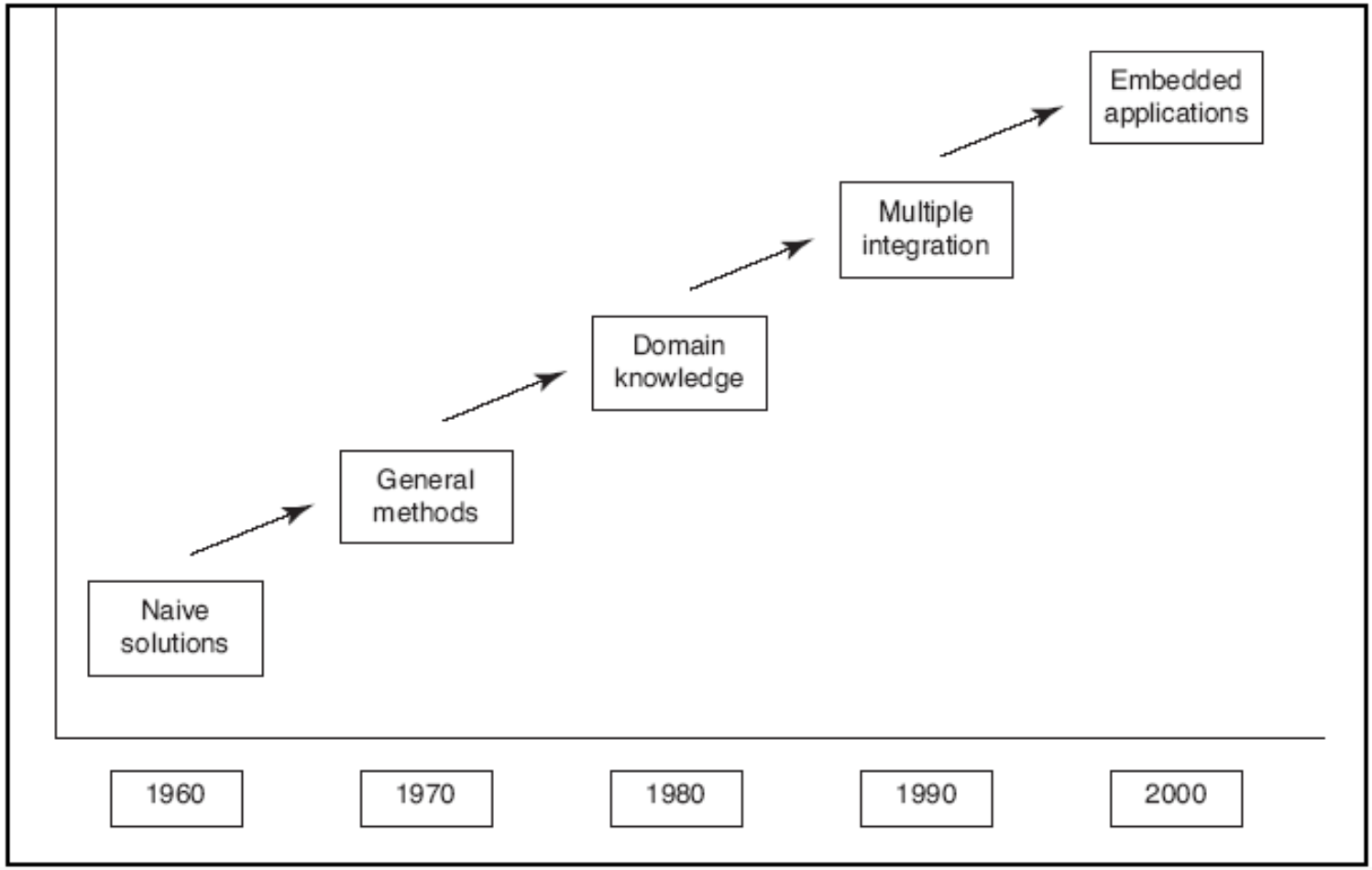
Concepts and Definitions of Artificial Intelligence

- Characteristics of artificial intelligence
  - Inferencing
    - Reasoning capabilities that can build higher-level knowledge from existing heuristics.
  - Machine learning
    - Learning capabilities that allow systems to adjust their behavior and react to changes in the outside environment.

Evolution of Artificial Intelligence

- Naïve solutions stage
  - Little understanding of human intelligence, overly optimistic, solutions created at that time were primitive.
- General methods stage
  - Focused on more effective problem solving such as knowledge representation, reasoning
- Domain knowledge stage
  - Applied the general-purpose methods to real-world applications
  - Expert system or a knowledge-based system
- Multiple integration stage
  - Integrate multiple techniques
- Embedded applications stage

The Artificial Intelligence Field



The Artificial Intelligence Field

- A useful application of artificial intelligence
  - **Expert system (ES)**
    - A computer system that applies reasoning methodologies to knowledge in a specific domain to render advice or recommendations, much like a human expert.
    - A computer system that achieves a high level of performance in task areas that, for human beings, require years of special education and training.

Basic Concepts of Expert Systems (ES)

- The basic concepts of ES include:
  - How to determine who experts are.
  - How expertise can be transferred from a person to a computer.
  - How the system works.

Basic Concepts of Expert Systems (ES)

- **Expert**

  A human being who has developed a high level of proficiency in making judgments in a specific, usually narrow, domain.

Basic Concepts of Expert Systems (ES)

- **Expertise**
  - A specialized type of knowledge and skill that experts have.
  - The implicit knowledge and skills of the expert that must be extracted and made explicit so that it can be encoded in an expert system.

Basic Concepts of Expert Systems (ES)

- Features of ES
  - Expertise
    - Possesses expertise for expert-level decisions
  - Symbolic reasoning
    - Knowledge represented by symbolic representation
  - Deep knowledge
    - Complex knowledge not easily known in non-experts
  - Self-knowledge
    - Examine its own reasoning; provide explanations

Basic Concepts of Expert Systems (ES)

- Other uses of ES
  - ES are an excellent tool for preserving professional knowledge crucial to a company's competitiveness.
  - ES is an excellent tool for documenting professional knowledge for examination or improvement.
  - ES is a good tool for training new employees and disseminating knowledge in an organization.
  - ES allow knowledge to be transferred more easily at a lower cost.

Application of expert systems

Class	General Area
Configuration	Assemble proper components of a system in the proper way.
Diagnosis	Infer underlying problems based on observed evidence.
Instruction	Intelligent teaching so that a student can ask *why*, *how,* and *what if* questions just as if a human were teaching.
Interpretation	Explain observed data.
Monitoring	Compares observed data to expected data to judge performance.
Planning	Devise actions to yield a desired outcome.
Prognosis	Predict the outcome of a given situation.
Remedy	Prescribe treatment for a problem.
Control	Regulate a process. May require interpretation, diagnosis, monitoring, planning, prognosis, and remedies.

Application of expert systems

Classic Chemistry Expert Systems

Name	Chemistry
CRYSALIS	Interpret a protein's 3-D structure.
DENDRAL	Interpret molecular structure.
TQMSTUNE	Remedy Triple Quadruple Mass Spectrometer (keep it tuned).
CLONER	Design new biological molecules.
MOLGEN	Design gene-cloning experiments.
SECS	Design complex organic molecules.
SPEX	Plan molecular biology experiments.

Application of expert systems

Classic Electronics Expert Systems

Name	Electronics
ACE	Diagnose telephone network faults.
IN-ATE	Diagnose oscilloscope faults.
NDS	Diagnose national communication net.
EURISKO	Design 3-D microelectronics.
PALLADIO	Design and test new VLSI circuits.
REDESIGN	Redesign digital circuits to new.
CADHELP	Instruct for computer-aided design.
SOPHIE	Instruct circuit fault diagnosis.

Application of expert systems

Classic Medical Expert Systems

Name	Medicine
PUFF	Diagnose lung disease.
VM	Monitors intensive-care patients.
ABEL	Diagnose acid-base/electrolytes.
AI/COAG	Diagnose blood disease.
AI/RHEUM	Diagnose rheumatoid disease.
CADUCEUS	Diagnose internal medicine disease.
ANNA	Monitor digitalis therapy.
BLUE BOX	Diagnose/remedy depression.
MYCIN	Diagnose/remedy bacterial infections.
ONCOCIN	Remedy/manage chemotherapy patients.
ATTENDING	Instruct in anesthetic management.
GUIDON	Instruct in bacterial infections.

Application of expert systems

Classic Engineering Expert Systems

Name	Engineering
REACTOR	Diagnose/remedy reactor accidents.
DELTA	Diagnose/remedy GE locomotives.
STEAMER	Instruct operation of steam powerplant.

Classic Geology Expert Systems

Name	Geology
DIPMETER	Interpret dipmeter logs.
LITHO	Interpret oil well log data.
MUD	Diagnose/remedy drilling problems.
PROSPECTOR	Interpret geological data for minerals.

Application of expert systems

Classic Computer Expert Systems

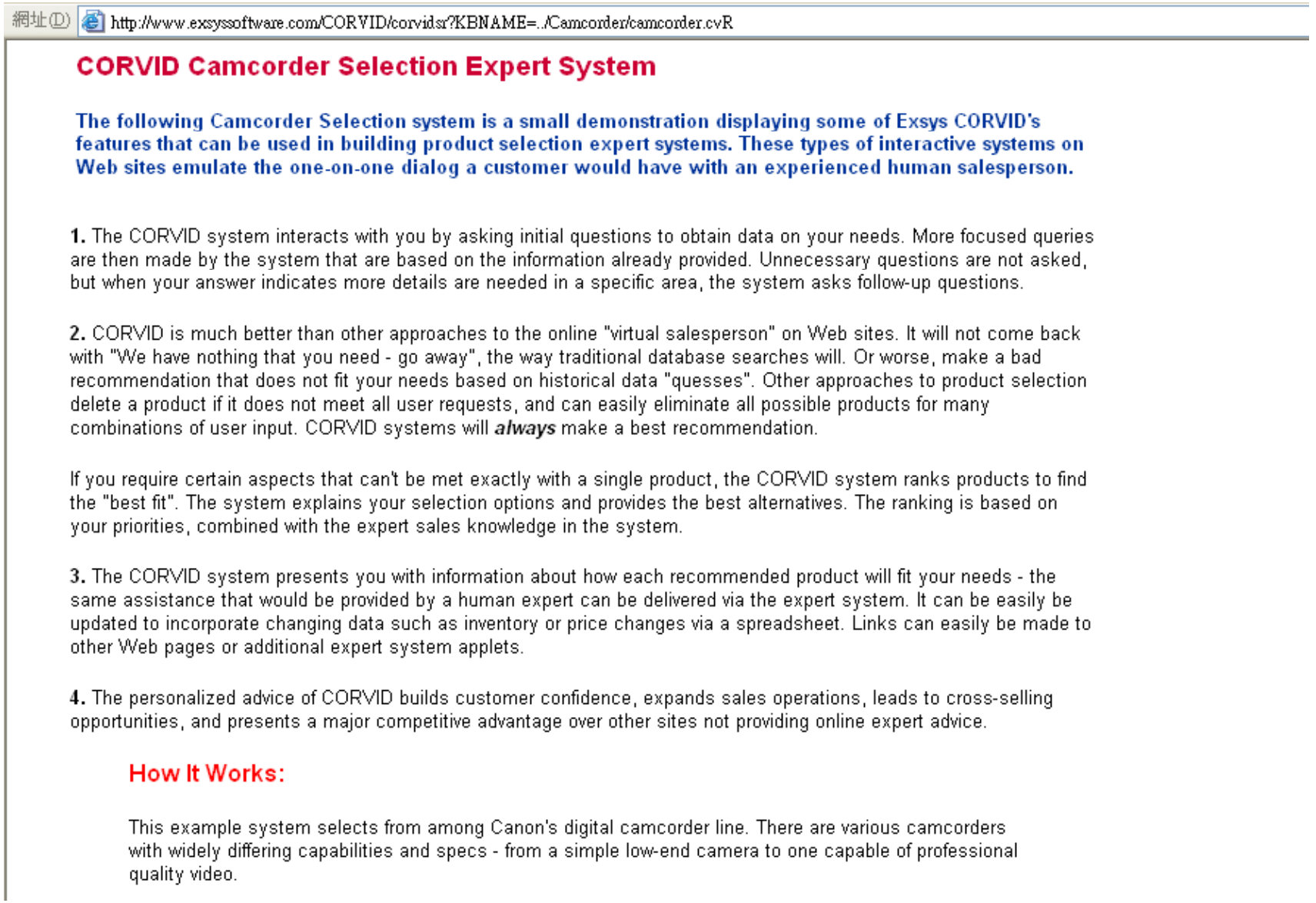
Name	Computer Systems
PTRANS	Give prognosis for managing DEC computers.
BDS	Diagnose bad parts in switching net.
XCON	Configure DEC computer systems.
XSEL	Configure DEC computer sales order.
XSITE	Configure customer site for DEC computers.
YES/MVS	Monitor/control IBM MVS operating system.
TIMM	Diagnose DEC computers.

Applications of ES

- Newer applications of ES
  - Credit analysis systems
  - Pension fund advisors
  - Automated help desks
  - Homeland security systems
  - Market surveillance systems
  - Business process reengineering systems

An Example of ES

http://www.exsys.com/demomain.html



網址(D) http://www.exsyssoftware.com/CORVID/corvidsr?KBNAME=../Camcorder/camcorder.cvR

CORVID Camcorder Selection Expert System

The following Camcorder Selection system is a small demonstration displaying some of Exsys CORVID's features that can be used in building product selection expert systems. These types of interactive systems on Web sites emulate the one-on-one dialog a customer would have with an experienced human salesperson.

1. The CORVID system interacts with you by asking initial questions to obtain data on your needs. More focused queries are then made by the system that are based on the information already provided. Unnecessary questions are not asked, but when your answer indicates more details are needed in a specific area, the system asks follow-up questions.

2. CORVID is much better than other approaches to the online "virtual salesperson" on Web sites. It will not come back with "We have nothing that you need - go away", the way traditional database searches will. Or worse, make a bad recommendation that does not fit your needs based on historical data "quesses". Other approaches to product selection delete a product if it does not meet all user requests, and can easily eliminate all possible products for many combinations of user input. CORVID systems will ***always*** make a best recommendation.

If you require certain aspects that can't be met exactly with a single product, the CORVID system ranks products to find the "best fit". The system explains your selection options and provides the best alternatives. The ranking is based on your priorities, combined with the expert sales knowledge in the system.

3. The CORVID system presents you with information about how each recommended product will fit your needs - the same assistance that would be provided by a human expert can be delivered via the expert system. It can be easily be updated to incorporate changing data such as inventory or price changes via a spreadsheet. Links can easily be made to other Web pages or additional expert system applets.

4. The personalized advice of CORVID builds customer confidence, expands sales operations, leads to cross-selling opportunities, and presents a major competitive advantage over other sites not providing online expert advice.

How It Works:

This example system selects from among Canon's digital camcorder line. There are various camcorders with widely differing capabilities and specs - from a simple low-end camera to one capable of professional quality video.

An Example of ES

How It Works:

This example system selects from among Canon's digital camcorder line. There are various camcorders with widely differing capabilities and specs - from a simple low-end camera to one capable of professional quality video.

The system asks the user questions about their previous use of camcorders, and their intended use for a new one. Based on this information, the system determines what features are needed. Product data is applied to a spreadsheet of information on the various Canon camcorders. The system's analysis creates a probabilistic ranking of the camcorders related to the customer needs. With the results, the top 3 recommended camcorders are displayed along with comments on their suitability.

All of the decision-making logic is kept separate from the product data. Generic camcorder selection logic is converted to rules using the CORVID development environment. These rules are applied to data on specific products stored in a spreadsheet. Including a new camcorder is as simple as adding it to the spreadsheet. If a feature on a camcorder changes, it is just edited in the spreadsheet.

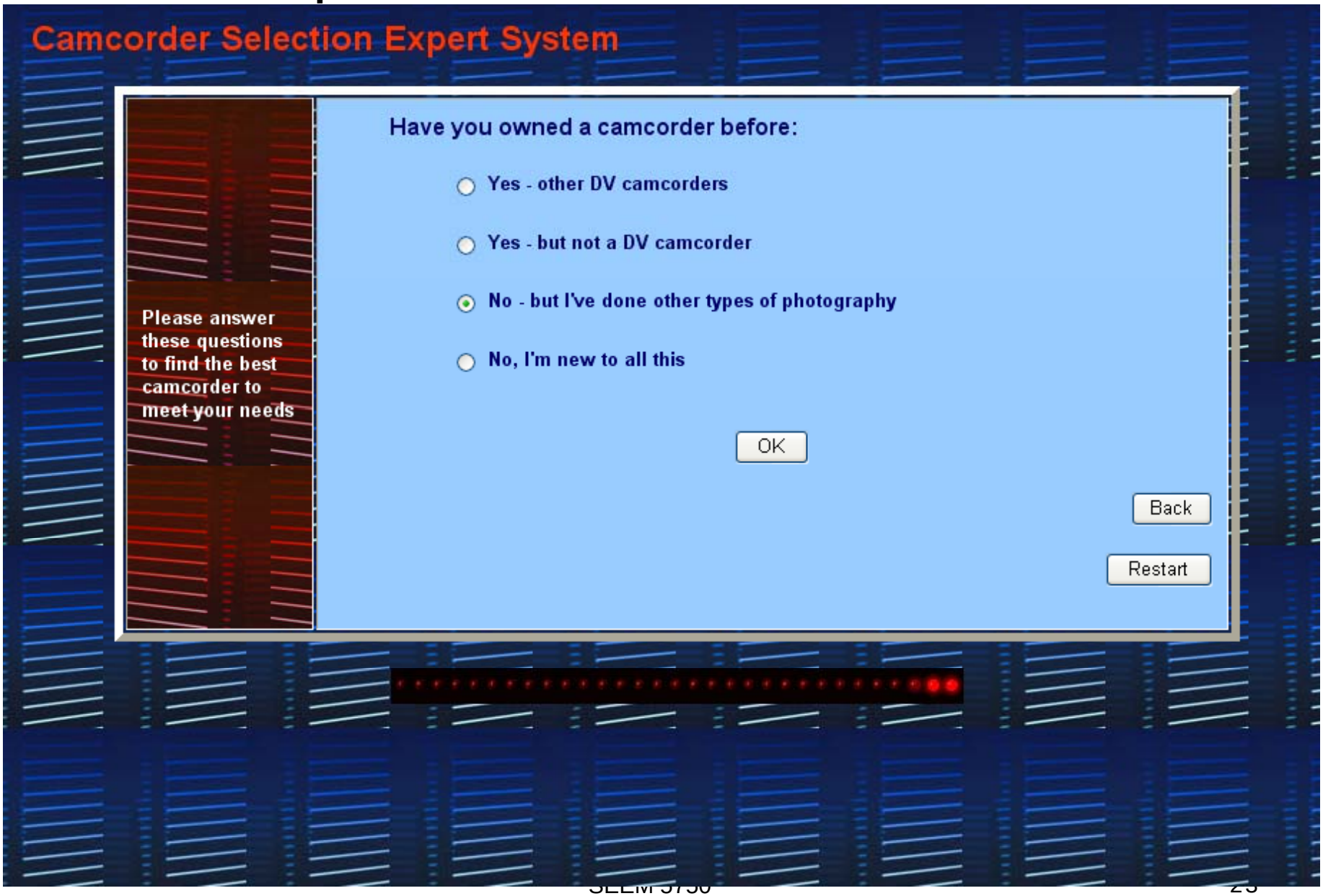
To see some of the features running the system, try changing various input values and see how the resulting recommendations change. Notice especially how the comments change as the priority of various options is changed. If "high quality audio" was requested, a camcorder with lower quality audio would have a warning that it's audio would not meet the customer needs. Dropping the audio requirement would lessen or eliminate this warning.

(This system does not imply any use or endorsement of Exsys CORVID by Canon, or Canon by EXSYS Inc.)

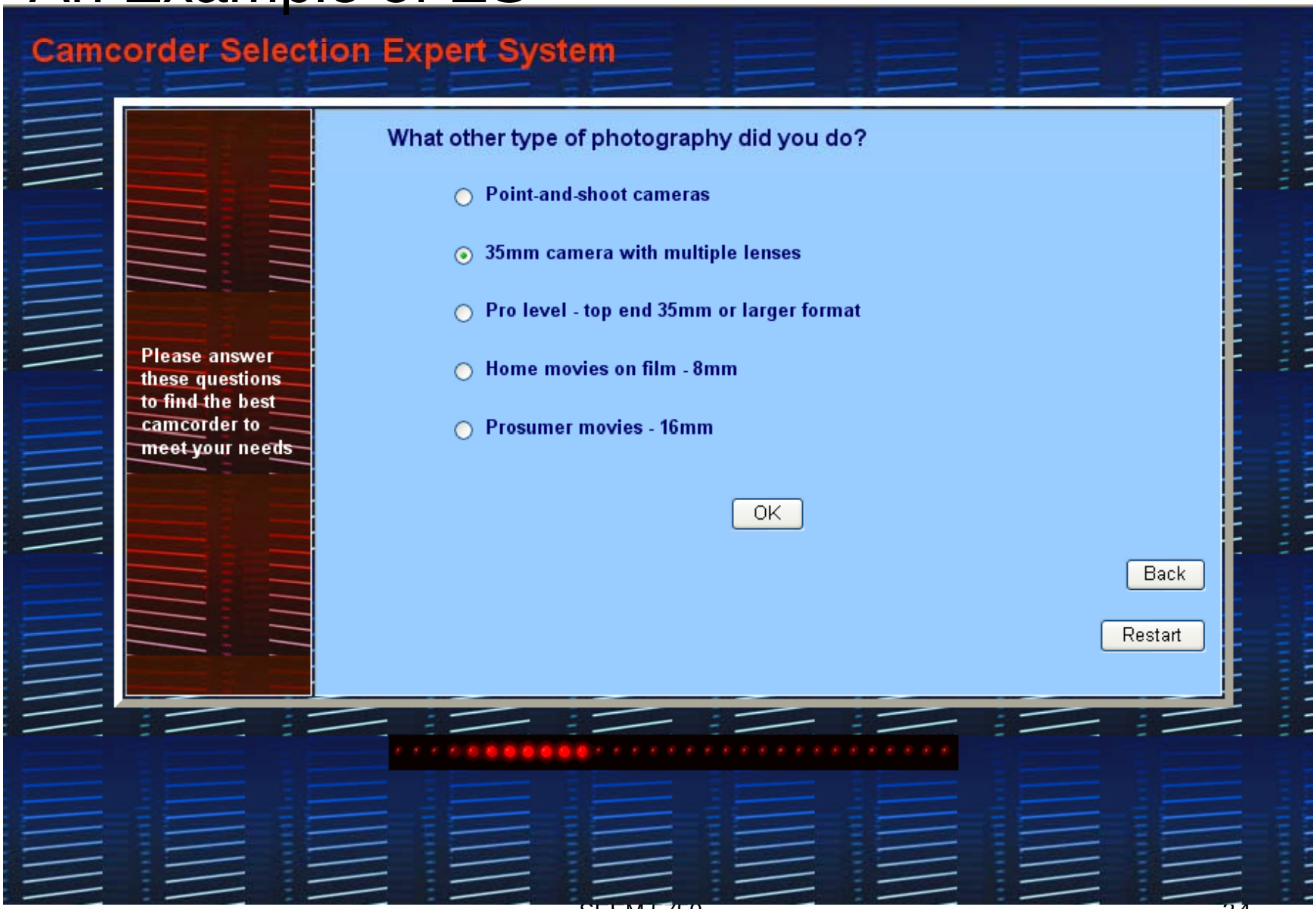
Start the Selector

Run this same system using the CORVID Applet Runtime

An Example of ES



An Example of ES



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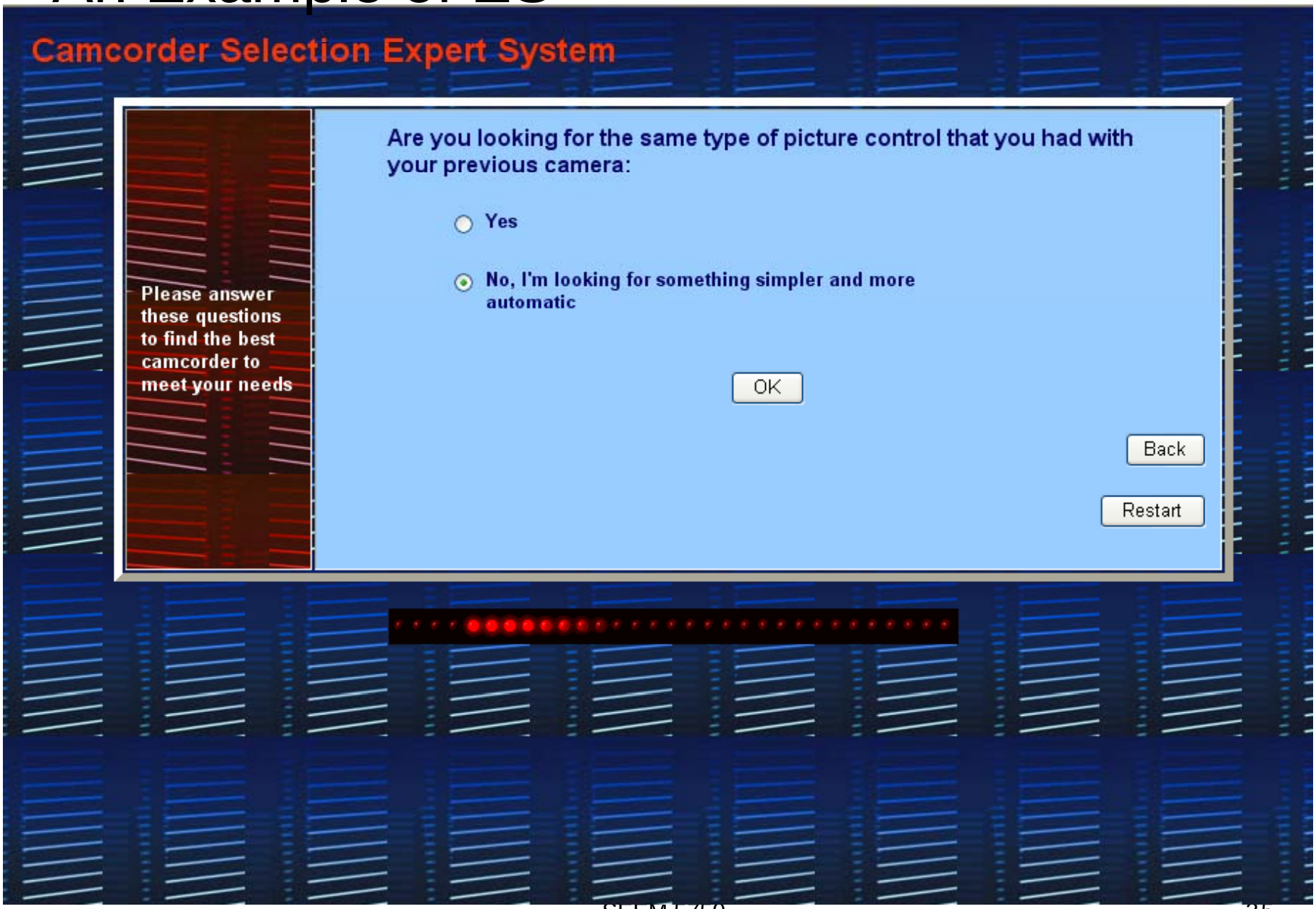

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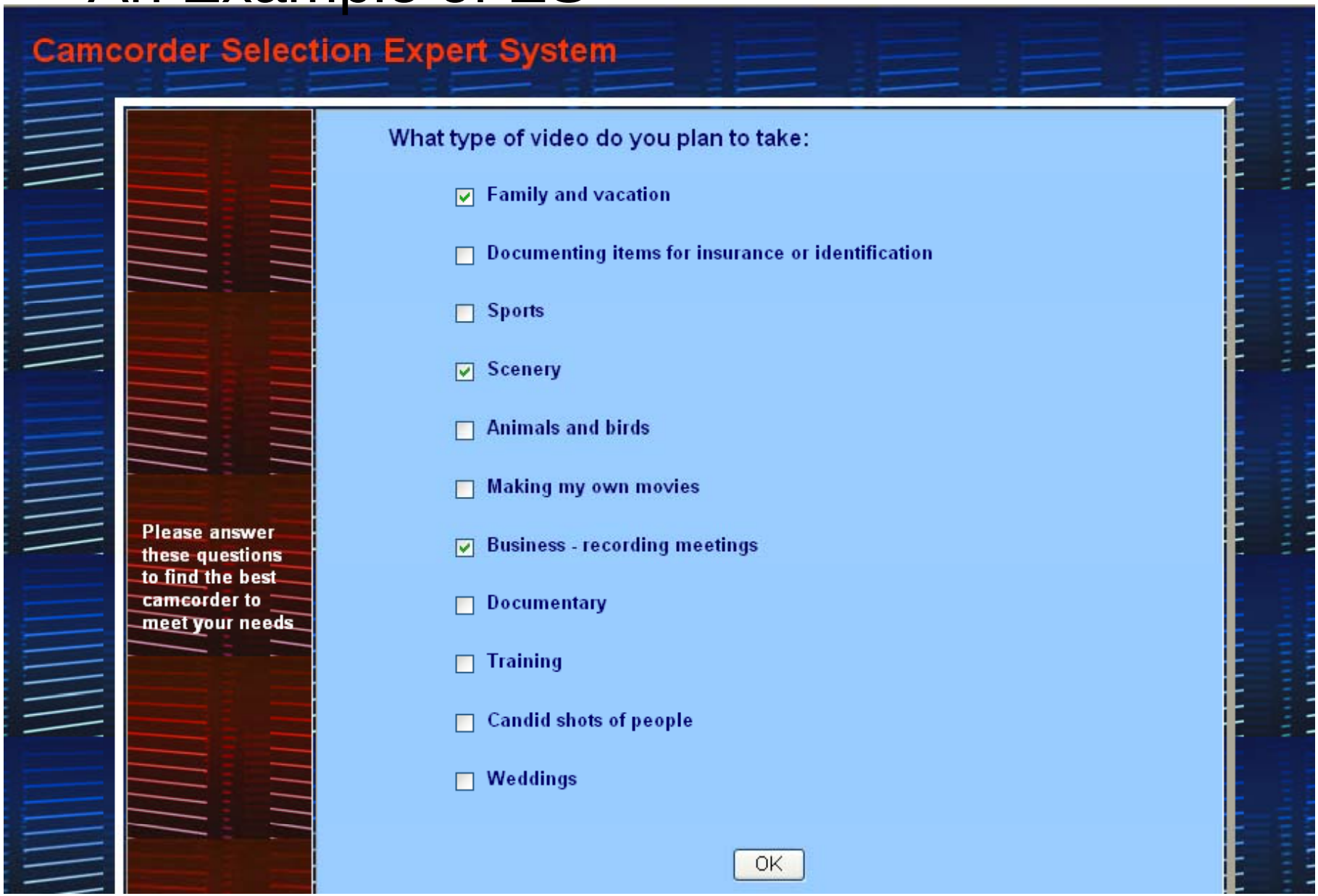

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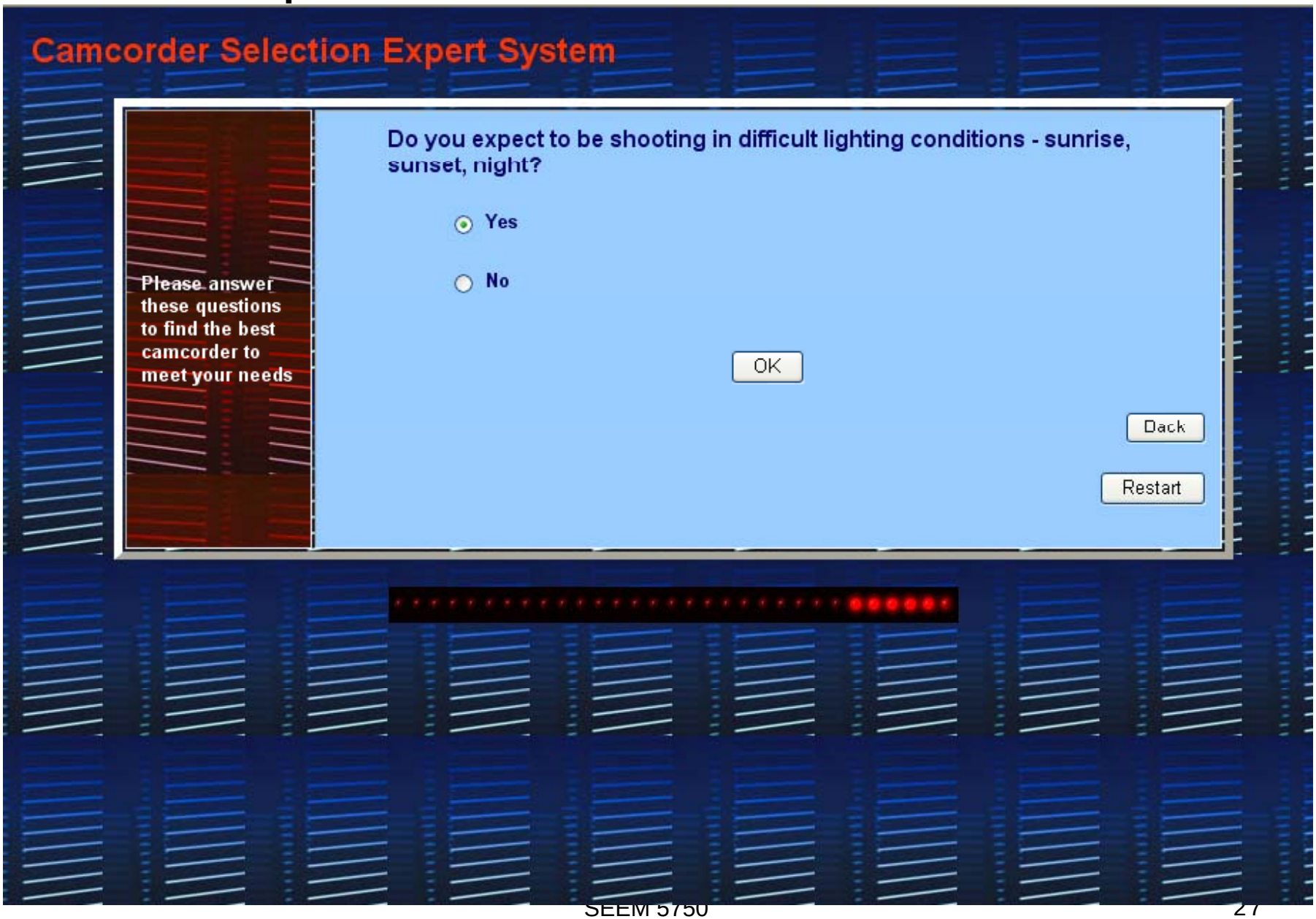

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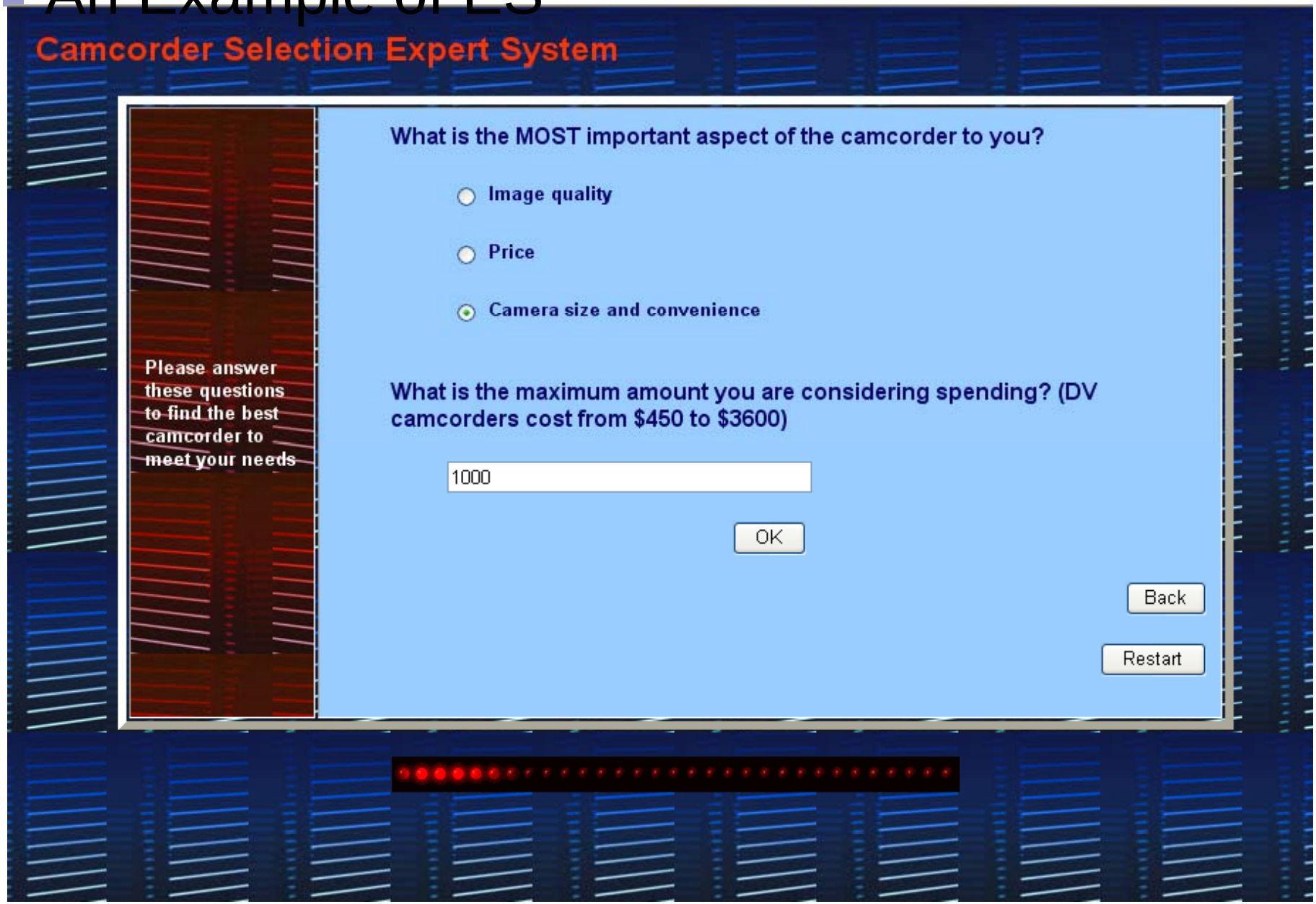

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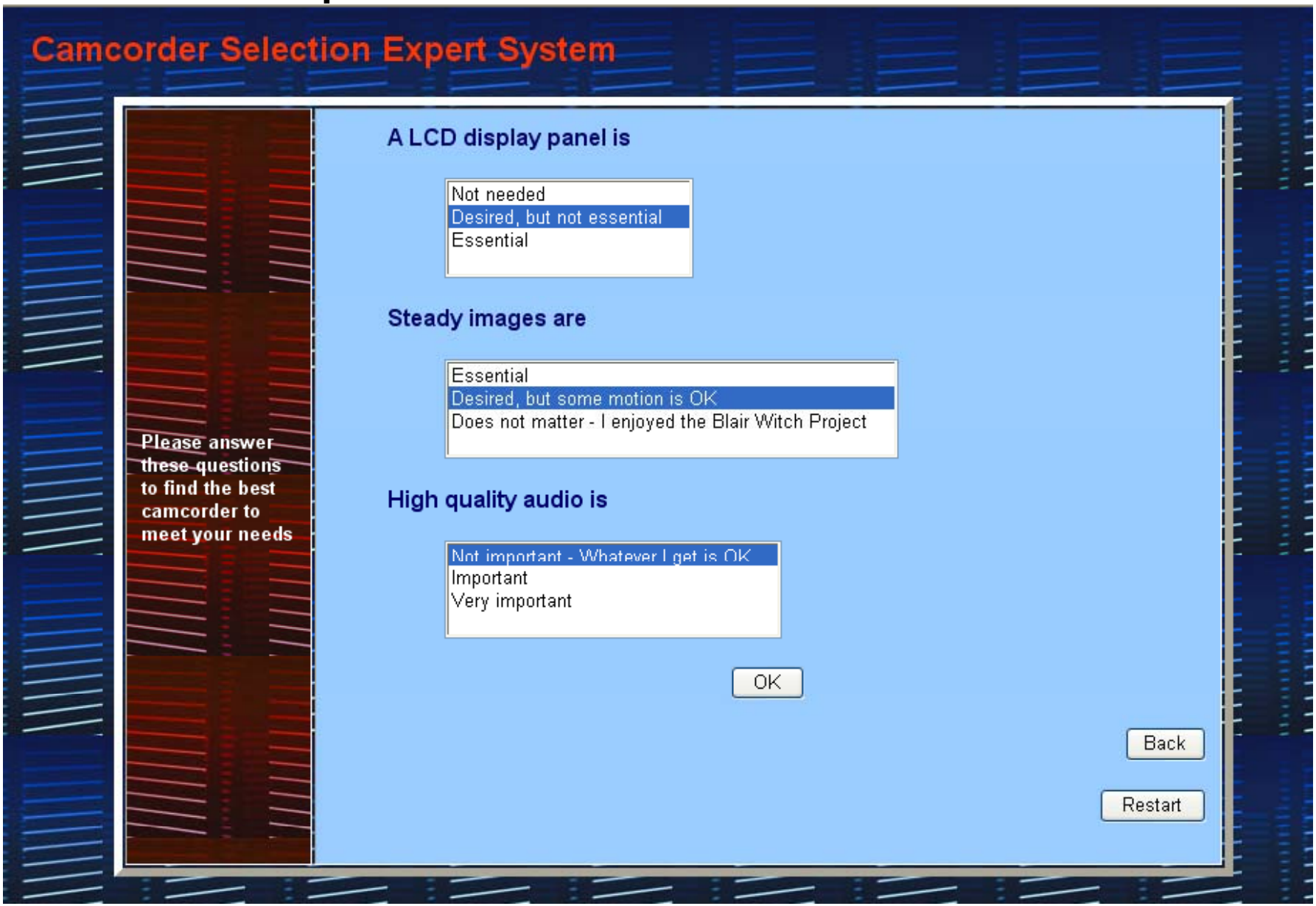

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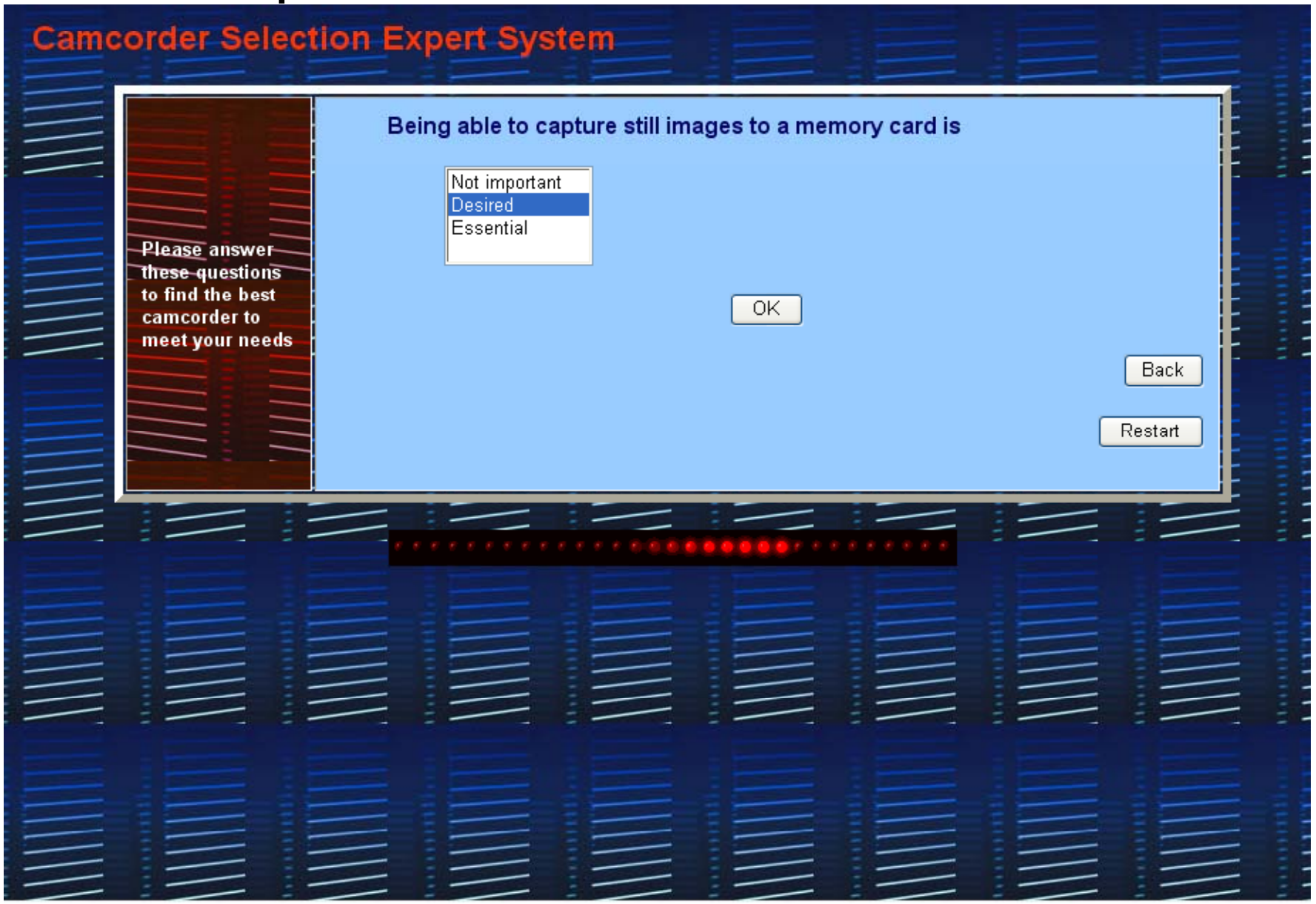


An Example of ES

Camcorder Selection Expert System

Results

Based on the other types of photography you have done and that you would like an easier to use video camera, I think you would prefer a point-and-shoot camcorder.

Elura 40MC ($750)

An excellent match to your requirements. Under your budget. An adequate stabilization system. A small and compact camcorder easily carried in a pocket. Not quite as good an image quality or as many features as the Optura, but suitable for general use.

ZR50MC ($570)

An excellent match to your requirements. Under your budget. A lower end stabilization system. An entry level DV camcorder. Also stores still images on a memory card that can be downloaded into a computer. A wider zoom range than the ZR40 ro ZR45.

ZR45MC ($500)

An excellent match to your requirements. Under your budget. A lower end stabilization system. A low priced basic entry level camcorder, but DV quality and much better than lower priced non-DV alternatives. Also stores still images on a memory card that can be downloaded into a computer.

Restart

Application of expert systems in Greater China

Expert Systems	Details
AOXS-RICH Automatic Optimization Expert System Automatic Frequency Optimization services include: Network interference models information collection and analysis, Model building and matching, scheme of automatic frequency optimization, scheme of model adjustment and implementation of frequency change and optimal adjustment after frequency change. (频率自动优化服务包括网络干扰模型信息采集与分析、模型建立和匹配、系统执行频率自动优化生成优化方案和模型校正方案、实施优化调整和执行换频、换频后的优化调整五个方面。)	http://www.tuoming.com.cn/en/pro_det.asp?info_kind=003001001&ID=1292
KDPExpert Expert System	http://www.siaaa.com/dianyuan/sj/200911/380480.html
Flood Control and Geographic Information System (防汛地理信息系统)	http://www.wavenet.com.cn/products_view.asp?id=7
Nutrition expert system (pediatric version) (营养专家系统:儿科版)	http://img.newhua.com/softinfo/47725/

Application of expert systems in Greater China

Expert Systems	Details
Yantai Spandex Company 20t / h chain furnace expert system FOCS (烟台氨纶公司20t/h链条炉FOCS专家系统)	http://www.gongkong.com/webpage/solutions/200211/5-A510-71997FC995F8.htm
Coking coal blending expert system (炼焦配煤专家系统)	http://www.dfmc.cc/product/product_50.html
Blast expert system (炼铁专家系统)	http://www.dfmc.cc/product/product_55.html
Guangxi Agricultural Expert System (广西农业专家系统)	http://d.wanfangdata.com.cn/Periodical_gxkxyxb200304019.aspx
BKS600 central air-conditioning management expert system (BKS600中央空调管理专家系统)	http://www.hthc.cn/view.asp?id=32
CounterWin CNC Lathe expert system (CounterWin CNC車床圖形專家系統)	http://www.renan.com.tw/counterwin.html

Application of expert systems in Greater China

Expert Systems	Details
Cobia fish disease diagnosis expert system (海鱸疾病診斷專家系統)	http://www.nvri.gov.tw/Module/PrintFriendly/Print.aspx?nid=BC6vIbU6CjA%3D&type=MFu70kAXgzY%3D
SPOTLIGHT APS Expert (神燈先進規劃排程專家系統)	http://www.action-soft.com.tw/index_TrdCn.htm
AICAMS (Artificial Intelligence Crime Analysis and Management System)	http://www.cuhk.edu.hk/iso/bulletin/issue/199902/E_aicams.htm

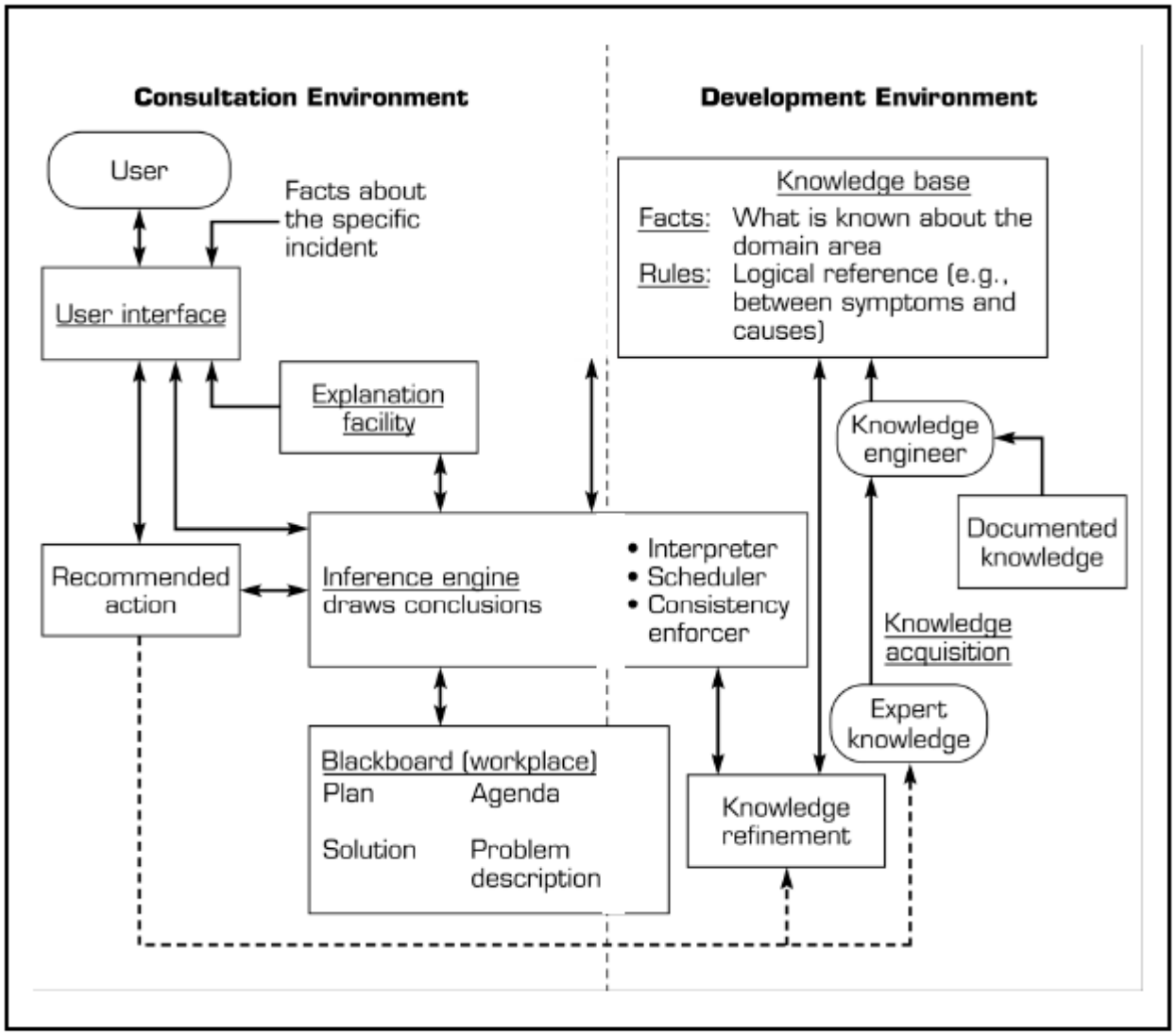
Structure of ES

- **Development environments**
  - Parts of expert systems that are used by builders. They include the knowledge base, the inference engine, knowledge acquisition, and improving reasoning capability.
  - The knowledge engineer and the expert are considered part of these environments.

Structure of ES

- **Consultation environment**
  - The part of an expert system that is used by a non-expert to obtain expert knowledge and advice.
  - It includes the workplace, inference engine, explanation facility, recommended action, and user interface.

Applications of ES



Structure of ES

- Three major components in most ES are:
  - Knowledge base
  - Inference engine
  - User interface
- ES may also contain:
  - Knowledge acquisition subsystem
  - Blackboard (workplace)
  - Explanation subsystem (justifier)
  - Knowledge refining system

Structure of ES

- **Knowledge acquisition (KA)**

  The extraction and formulation of knowledge derived from various sources, especially from experts.

- **Knowledge base**

  A collection of facts, rules, and procedures organized into schemas. The assembly of all the information and knowledge about a specific field of interest.

Structure of ES

- **Inference engine**

  The part of an expert system that actually performs the reasoning function.

- **User interfaces**

  The parts of computer systems that interact with users, accepting commands from the computer keyboard and displaying the results generated by other parts of the systems.

Structure of ES

- **Blackboard *(workplace)***

  An area of working memory set aside for the description of a current problem and for recording intermediate results in an expert system.

- **Explanation subsystem *(justifier)***

  The component of an expert system that can explain the system's reasoning and justify its conclusions.

How ES Work: Inference Mechanisms

- Knowledge representation and organization
  - Expert knowledge must be represented in a computer-understandable format and organized properly in the knowledge base.
  - Different ways of representing human knowledge include:
    - Production rules
    - Semantic networks
    - Logic statements

How ES Work: Inference Mechanisms

- The inference process

  Inference is the process of chaining multiple rules together based on available data

How ES Work:

Examples of Inference Mechanisms

- **Forward chaining**

  A data-driven search in a rule-based system

- **Backward chaining**

  A search technique (employing IF-THEN rules) used in production systems that begins with the action clause of a rule and works backward through a chain of rules in an attempt to find a verifiable set of condition clauses.

Forward chaining vs Backward chaining

A: Have $10,000

B: Younger than 28

C: Education at University level

D: Monthly income of at least $30,000

E: Invest in securities

F: Invest in growth stocks

G:Invest in HSBC stock

R1: If A and C Then E.

R2: If D and C Then F.

R3: If B and E Then F.

R4: If B Then C.

R5: If F Then G.

An investor has $10,000 (A is true) and he is 24 years old (B is true. He would like advice on investing in HSBC stock (goal)

Selecting the Building Tools

- General-purpose development environment
  - e.g., C++, Prolog, LISP
  - They don’t have the built-in inference capability, therefore, they are very costly.
- **Expert system shell**
  - A computer program that facilitates relatively easy implementation of a specific expert system.
  - KB is empty. System development is therefore a process of feeding KB.
  - CLIPS is an expert system building tool.