Blue eye technology

(blue eyes – Human operator monitoring system)

BY
Agenda

- Motivation
- What is BlueEye technology?
- What is BlueEyes?
- System designing
- System overview
- DAU
- CSU
- Data security
- IBM research
- Conclusion
Motivation

- Human error - a frequent reason of catastrophes and ecological disasters
  - temporal indisposition
  - weariness
  - oversight
- Monitoring of conscious brain involvement
- Lack of complex solution exploiting wireless link technology, database systems and AI algorithms
What is blue eye technology?

The BLUE EYES technology aims at creating computational machines that have perceptual and sensory ability like those of human beings.
How can we make computers “see” and “feel”?

- Blue eyes uses sensing technology to identify a user’s actions and to extract key information.
- Information is then analyzed to determine the user’s physical, emotional, or informational state.
What is Blue Eyes?

- The complex solution for human-operator monitoring:
  - Visual attention monitoring
  - Physiological condition
  - Operator’s position detection
  - Wireless data acquisition using bluetooth
What is BlueEyes not?

- Doesn’t predict nor interfere with operator’s thoughts
- Cannot force directly the operator to work
IBM research

- BLUE EYE – EMOTIONAL MOUSE
  sensors in the mouse, sense the physiological attributes which are correlated to emotions using correlation model
  - by simply touching the mouse, the computer will be able to determine a person’s emotional state.

- BLUE EYE enabled TELEVISION – could become active when the user makes an eye contact.
Physiological foundations

Preconscious brain
- alogical
- “automatic”

Conscious brain
- manages the knowledge
- logical reasoning
- makes decisions
Conscious brain - operation

Exploratory mode

Planning mode
The eye movement sensor

- Off-shelf eye movement sensor – Jazz multisensor
- Supplies raw digital data regarding
  - Eye position
  - Level of blood oxygenation
  - Acceleration along horizontal and vertical axes
  - Ambient light intensity
Eye movements

- Retina - central vision (macula)
- Central vision and the conscious brain

*Saccade* - a rapid eye jump to a new location assigned by the conscious attention process.

Saccades presence Exploratory mode
Jazz multisensor

Jazz Multisensor
Jazz
Design objectives

- A mobile data acquisition device
  - A reliable real-time buffering, processing and recording
  - A clear visualization interface
  - Mechanisms for creating custom data analyzers
  - To ensure a possibility of distributing the processing among a number of computers
Implementation and engineering

- THREE groups of users
  - OPERATOR - a person whose physiological parameters are supervised
    - authorization in the system
    - receiving alerts
  - SUPERVISOR – a person responsible for analyzing operator’s condition and performance.
  - SYSTEM ADMINISTRATORS- maintains the system deliver tools for adding
    - new operator’s to the database
    - defining alarm conditions
    - configuring logging tools
    - creating new analyzer modules
Designing

- A personal area network for linking all the operators and the supervising system
- Two major units
  - DAU (data acquisition unit)
  - CSU (central system unit)
Bluetooth technology provides means for creating a Personal Area Network linking the operators and the central system.
The DAU consists of the following components:

- ATMEL 8952 microcontroller
- BLUE TOOTH MODULE – supports synchronous voice data transmission
- PCM CODEC – used to transmit operator’s voice and central system sound feedback
- UART – communication between bluetooth module and microcontroller (115200 bps)
- MAX232 – level shifter
- ALPHANUMERIC LCD display
- LED indicators
- ID CARD interface
DAU - features

- Lightweight
- Runs on batteries - low power consumption
- Easy to use - does not disturb the operator working
- ID cards for operator authorization
DAU - components

BlueEyes
Data Acquisition Unit
Microcontroller & blue tooth module
EEPROMS & the PCB
Implementation - DAU

- Made from scratch by the team
- Bluetooth module inside
- Jazz sensor interface
- Microphone and earphone sockets
- 5-key keyboard
- Two lines, 8 characters LCD
- Powered from 6 AA batteries
Implementation - DAU

Bluetooth module
PCM codec board
Batteries and voltage level monitor
Microcontroller board
CSU - features

- Connection management
- Data processing
- Visualization
- Data recording
- Access verification
- System maintenance
CSU – components

- CONNECTION MANAGER – main task to perform low-level blue tooth communication
- DATA ANALYSIS MODULE – performs the analysis of the raw sensor data in order to obtain information about operator’s physiological condition
- DATA LOGGER MODULE – provides support for storing the monitored data.
- VISUALIZATION MODULE – provides user interface for the supervisors
CSU - Visualization Module

- Raw and processed data visualization using:
  - VU-meters
  - pie-charts
  - time series

- audio and video data playback
CSU - saccade detector

- Saccade detector and conscious brain involvement level calculation

Differentiation

Eye movement velocity

Visual attention level

Conscious brain involvement level
CSU - Connection Manager

- Initiates Bluetooth modules
- Inquires for new devices in range
- Establishes connections
- Supports operator roaming
- Feeds Operator Manager with physiological data

- Data demultiplexer
- Data producer queues

- Raw Data Buffer
- Alert buffer

- Bluetooth Connection Manager
CSU - Data Analysis

- Custom data analyzers - decision tree based classifiers
- Automatic decision tree coefficients generation - C4.5 based algorithm
CSU - Data Analysis

- Custom data analyzers - decision tree based classifiers

Example: Operator gesture recognition (simplified)

```
Vertical Acceleration variance value high
Horizontal Acceleration variance high

Y       N

N       Y       N       Y

"YES"   No answer "NO"
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CSU - intermodule communication

- Uses buffered thread-safe queues and producer-consumer scheme

- Data producer creates Data queue

- register at Data queue

- Data consumer & producer

- Data consumer

- Data queue
CSU - intermodule communication

Connection Manager

Operator manager (OM)

Separated physiological data streams

Alerts

Data Analysis

Visualization Module

Data Logger

Processed data

Recorded (off-line) data
Implementation - CSU

- Standard MDI user interface
- Custom-built Bluetooth communication routines
- Intel USB camera
- ID card programmer
- Developed using Visual C++ 6.0
- Deployment environment: Windows 2000, MS SQL Server
Future improvements

DAU
small CMOS camera to monitor the operator’s point of gaze
single PCB (SMD technology)
low voltage ICs - LiIO batteries
power

CSU
data mining algorithms
advanced database encryption
using e.g. AES algorithm
Data security

- Only registered mobile devices can connect to the system
- Bluetooth connection authentication
- Bluetooth connection encryption
- Access rights restrictions
- Personal and physiological data encryption
Applications of Blue Eyes

- Generic control rooms
  (System can be applied in every working environment requiring permanent operator’s attention)
  - Power station
  - Captain bridge
  - Flight control centers
  - Operating theatres – anesthesiologists
Blue Eyes - benefits

- Prevention from dangerous incidents
- Minimization of
  - ecological consequences
  - financial loss
  - a threat to a human life
- The reconstruction of the course of operator’s work
References

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Conclusion

- In the near future, ordinary household devices—such as television, refrigerators, ovens—may be able to do their jobs when we look at them and speak to them.
- Future applications of blue eye technology is limitless.
Thank you