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Human brain interaction and motion perception by blue eyes technology

Upasana Arya and Mohit Giri Goswami
Astt. Professor, Amrapali Institute of Technology & Sciences, Haldwani, (Uttrakhand), India

ABSTRACT: This paper describes a framework for perception creation from sensor data. We propose using data abstraction techniques, in particular Symbolic Aggregate Approximation (SAX), to analyse and create patterns from sensor data. The created patterns are then linked to semantic descriptions that define thematic, spatial and temporal features, providing highly granular abstract representation of the raw sensor data. This helps to reduce the size of the data that needs to be communicated from the sensor nodes to the gateways or highlevel processing components. We then discuss a method that uses abstract patterns created by SAX method and occurrences of different observations in a knowledge-based model to create perceptions from sensor data.

Advances in cognitive neuroscience and brain imaging technologies have started to provide us with the ability to interface directly with the human brain. This ability is made possible through the use of sensors that can monitor some of the physical processes that occur within the brain that correspond with certain forms of thought. We have used these technologies to build brain-computer interfaces (BCIs), communication systems that do not depend on the brain's normal output pathways of peripheral nerves and muscles. In these systems, users explicitly manipulate their brain activity instead of using motor movements to produce signals that can be used to control computers or communication devices. Human-Computer Interaction (HCI) we explore possibilities that allow computers to use as many sensory channels as possible.

I. INTRODUCTION

We have started to consider implicit forms of input, that is, input that is not explicitly performed to direct a computer to do something. We attempt to infer information about user state and intent by observing their physiology, behavior, or the environment in which they operate. Using this information, systems can dynamically adapt themselves in order to support the user in the task at hand. BCIs are now mature enough that HCI researchers must add them to their tool belt when designing novel input techniques. In this introductory chapter to the book we present the novice reader with an overview of relevant aspects of BCI and HCI, so that hopefully they are inspired by the opportunities that remain.

Blue Eyes system provides technical means for monitoring and recording the operator's basic physiological parameters. The most important

parameter is saccadic activity, which enables the system to monitor the status of the operator's

Visual attention along with head acceleration, which accompanies large displacement of the visual axis. Complex industrial environment can create a danger of exposing the operator to toxic substances, which can affect his cardiac, circulatory and pulmonary systems. Thus, on the grounds of plethysmographic signal taken from the forehead skin surface, the system computes heart beat rate and blood oxygenation.

The Blue Eyes system checks above parameters against abnormal (e.g. a low level of blood oxygenation or a high pulse rate) or undesirable (e.g. a longer period of lowered visual attention) values and triggers user-defined alarms when necessary. This paper is about the hardware, software, benefits and interconnection of various parts involved in the "blue eye" technology.

Toward this end, the Blue Eyes aims at creating computational devices with the sort of perceptual abilities that people take for granted Blue eyes is being developed by the team of Poznan University of Technology& Microsoft. It makes use of the "blue tooth technology developed by Ericsson.

What Is Blue Eyes?

- BLUE EYES is a technology, which aims at creating computational machines that have perceptual and sensory abilities like those of human beings.

- The basic idea behind this technology is to give computer human power.
- For example, we can understand humans' emotional state by his facial expressions. If we add these perceptual abilities to computers, we would enable them to work together with human beings as intimate partners.
- It provides technical means for monitoring and recording human-operator's physiological condition.

Key features of the system

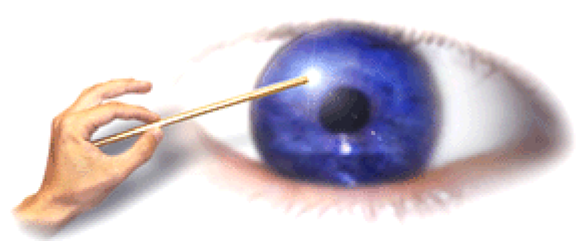
- Visual attention monitoring (eye motility analysis).
- Physiological condition monitoring (pulse rate, blood oxygenation).
- Operator's position detection (standing, lying).
- Wireless data acquisition using Bluetooth technology.
- Real-time user-defined alarm triggering.
- Physiological data, operator's voice and overall view of the control room recording recorded data playback.

Why it's named 'Blue Eyes'?

BlueEyes emphasizes – Bluetooth technology and the movements of the eyes. Bluetooth provides reliable wireless communication whereas the eye movements enable us to obtain a lot of interesting and important information.

(Manual Acquisition With **Gaze Initiated Control)**

By using MAGIC when the user looks at a target on the screen and touches the input device, the cursor appears in the target area indicated by gaze. Current gaze-tracking technology is accurate to within about a degree -- half an inch or so on a typical screen. The user then manually controls the cursor to the target point and uses buttons of the input device for selection.



The beauty of MAGIC is that it enables the hand and the eye to do what each does best. This approach takes advantage of the eye to reduce the effort required for manual pointing.

To the user, pointing is still done by the hand, the natural organ for manipulation, but the cursor always appears in about the right place needed, as if by magic. Previous efforts for such methods failed, because they tried to force the eye to perform a task better suited to the hand.

(Simple User Interest Tracker)

Just as a person normally expects a certain kind of engagement when interacting with another person, so should a person be able to expect similar engagement when interacting with a computational device. Such engagement requires the computer to carefully observe the user, anticipating user actions, needs, and desires. Such engagement enables users to begin to build personal relationships with computers. This is the aim of the SUITOR project.

SUITOR implements this method for putting computational devices in touch with their users' changing information needs. By paying constant attention to what a computer user does, Suitor can infer what sorts of information that will likely be most interesting at any moment and can then deliver that information on the spot.

For example, by watching what web page the user is browsing, Suitor can find additional information on the same topic. By watching where on the screen the user is actually reading, Suitor can more precisely determine the current topic of interest. To provide the user with additional information, Suitor can display text in a scrolling news ticker display, create a personalized web page, or deliver the information to a hand held device such as a PalmPilot.

The key is that a user simply interacts with the computer as usual -- reading, typing, clicking -- and the computer infers user interest based on what it sees the user do.

II. WORKING

The major parts in the Blue eye system are Data Acquisition Unit and Central System Unit. The tasks of the mobile Data Acquisition Unit are to maintain Bluetooth connections, to get information from the sensor and sending it over the wireless connection, to deliver the alarm messages sent from the Central System Unit to the operator and handle personalized ID cards. Central System Unit maintains the other side of the Bluetooth connection, buffers incoming sensor data, performs on-line data analysis, records the conclusions for further exploration and provides visualization interface.

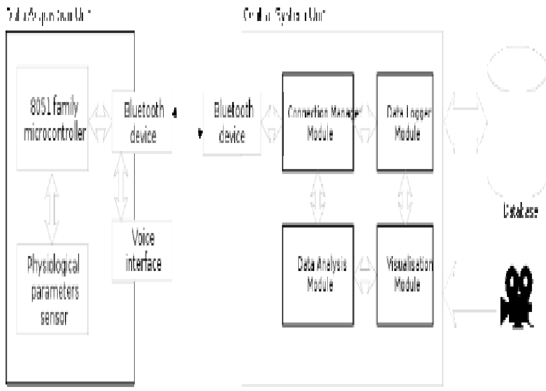


Fig. 1. Overall system diagram.

III. PART OF BLUE EYE TECHNOLOGY

The main parts in the Blue eye system are

1. Data Acquisition Unit
2. Central System Unit

Data Acquisition Unit (DAU)

Data Acquisition Unit is a mobile part of the Blue eyes system. Its main task is to fetch the physiological data from the sensor and to send it to the central system to be processed. To accomplish the task the device must manage wireless Bluetooth connections (connection establishment, authentication and termination). Personal ID cards and PIN codes provide operator's authorization. Communication with the operator is carried on using a simple 5-key keyboard, a small LCD display and a beeper. When an exceptional situation is detected the device uses them to notify the operator. Voice data is transferred using a small headset, interfaced to the DAU with standard mini-jack plugs.

To provide the Data Acquisition Unit with necessary physiological data we decided to purchase an off-shelf eye movement sensor – *Jazz Multisensor.* It supplies raw digital data regarding eye position, the level of blood oxygenation, acceleration along horizontal and vertical axes and ambient light intensity. Eye movement is measured using direct infrared oculographic transducers. The eye movement is sampled at 1 kHz, the other parameters at 250 Hz. The sensor sends approximately 5,2kB of data per second.

2. Hardware specification

We have chosen Atmel 8952 microcontroller to be the core of the Data Acquisition Unit since it is a well-established industrial standard and provides necessary functionality (i.e. high speed serial port) at a low price. The figure below shows the other DAU components.

Since the Bluetooth module we received supports synchronous voice data transmission (SCO link).

We decided to use hardware *PCM codec* to transmit operator's voice and central system sound feedback. The codec that we have employed reduces the microcontroller's tasks and lessens the amount of data being sent over the UART. Additionally, the Bluetooth module performs voice data compression, which results in smaller bandwidth utilization and better sound quality. Communication between the Bluetooth module and the microcontroller is carried on using standard UART interface.

The *alphanumeric LCD display* (two 8-character lines) gives more information of incoming events and helps the operator enter PIN code

The *LED indicators* show the results of built-in self-test, power level and the state of wireless connection.

The *simple keyboard* is used to react to incoming events (e.g. to silence the alarm sound) and to enter PIN code while performing authorization procedure.

ID card interface helps connect the operator's personal identification card to the DAU. After inserting the card authorization procedure starts.

1. Physiological data sensor

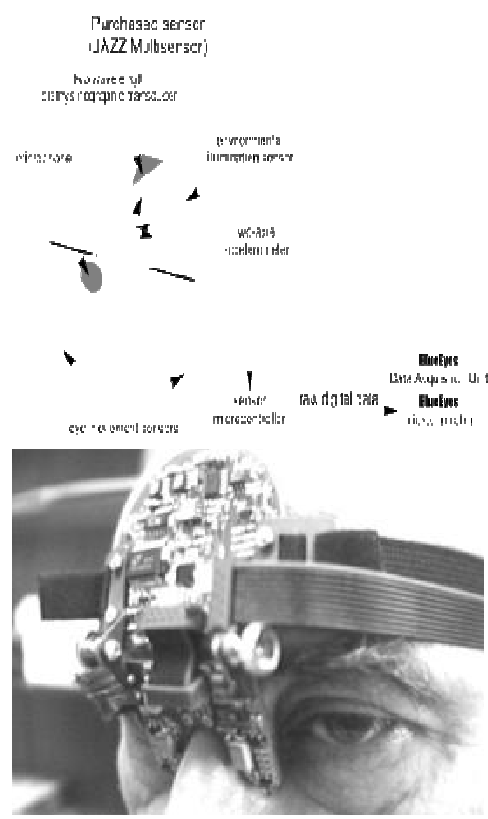


Fig. 2. Jazz Multisensor.

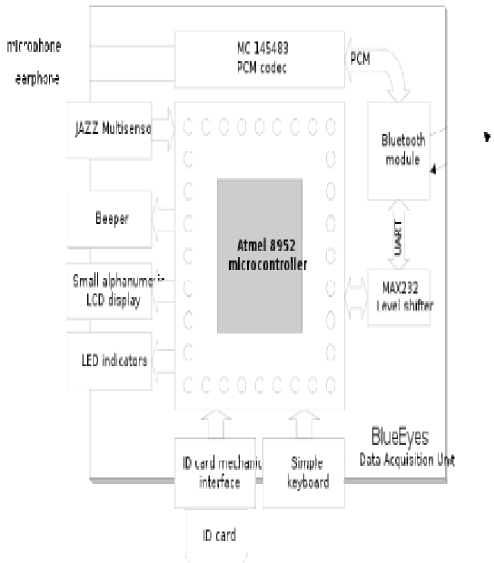


Fig. 3. DAU hardware diagram.

In the commercial release a cryptographic processor should be used instead. Each ID card is programmed to contain: operator's unique identifier, device access PIN code the operator enters on inserting his ID card and system access PIN code that is used on connection authentication. The operator's unique identifier enables the supervising system to distinguish different operators.

3. Microcontroller software specification

All the DAU software is written in 8051 assembler code, which assures the highest program efficiency and the lowest resource. At a low-level design stage we modeled the software using a state diagram. Such a diagram facilitates implementation, debugging and testing phases.

Central System Unit (CSU)

Central System Unit hardware is the second peer of the wireless connection. The box contains a Bluetooth module and a PCM codec for voice data transmission. The module is interfaced to a PC using a parallel, serial and USB cable. The audio data is accessible through standard mini jack sockets.

To program operator's personal ID cards we developed a simple programming device. The programmer is interfaced to a PC using serial and PS/2(power source) ports. Inside, there is Atmel 89C2051 microcontroller, which *handles UART transmission and I2C EEPROM (ID card) programming*. In this section we describe the four main CSU modules (see Fig. 1): Connection Manager, Data Analysis, Data Logger and Visualization.

1. Connection Manager

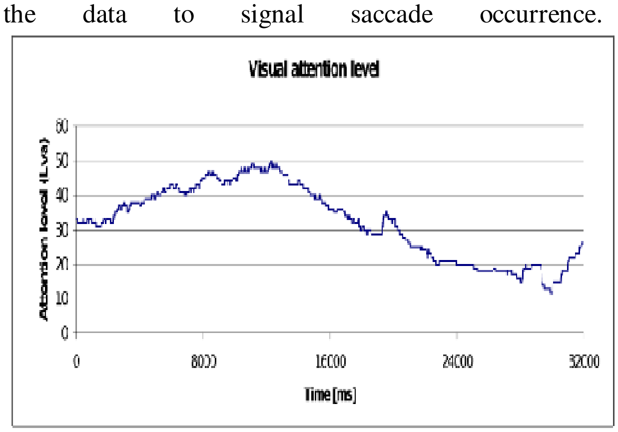
It is responsible for managing the wireless communication between the mobile Data Acquisition Units and the central system. The Connection Manager handles:

- communication with the CSU hardware
- searching for new devices in the covered range
- establishing Bluetooth connections
- connection authentication
- incoming data buffering
- sending alerts

2 . Data Analysis Module

The module performs the analysis of the raw sensor data in order to obtain information about the operator's physiological condition. The separately running Data Analysis Module supervises each of the working operators. The module consists of a number of smaller analyzers extracting different types of information. Each of the analyzers registers at the appropriate Operator Manager or another analyzer as a data consumer and, acting as a producer, provides the results of the analysis. An analyzer can be either a simple signal filter (e.g. Finite Input Response (FIR) filter) or a generic data extractor (e.g. signal variance, saccade detector) or a custom detector module. As we are not able to predict all the supervisors' needs, the custom modules are created by applying a supervised machine learning algorithm to a set of earlier recorded examples containing the characteristic features to be recognized. In the prototype we used an improved C4.5 decision tree induction algorithm. The computed features can be e.g. the operator's position (standing, walking and lying) or whether his eyes are closed or opened.

As built-in analyzer modules we implemented a saccade detector, visual attention level, blood oxygenation and pulse rate analyzers. The *saccade detector* registers as an eye movement and accelerometer signal variance data consumer and uses the data to signal saccade occurrence.



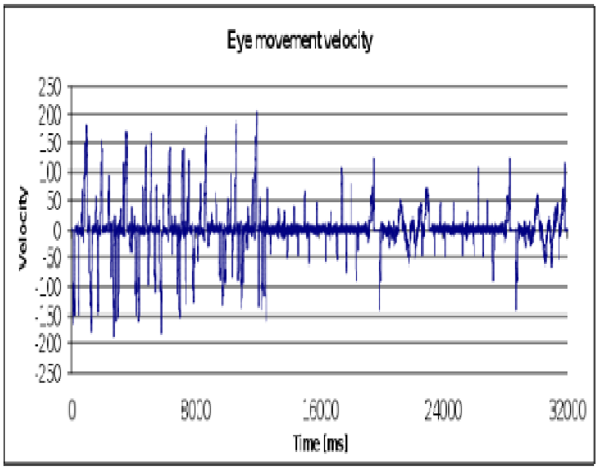


Fig. 4. Saccade occurrences and visual attention level.

Since saccades are the fastest eye movements the algorithm calculates eye movement velocity and checks physiological constraints.

The *visual attention level analyzer* uses as input the results produced by the saccade detector. Low saccadic activity (large delays between subsequent saccades) suggests lowered visual attention level (e.g. caused by thoughtfulness). Thus, we propose a simple algorithm that calculates the visual attention level (L_{va}): $L_{va} = 100/t_{s10}$, where t_{s10} denotes the time (in seconds) occupied by the last ten saccades. Scientific research has proven that during normal visual information intake the time between consecutive saccades should vary from 180 up to 350 ms. this gives L_{va} at 28 up to 58 units. The values of L_{va} lower than 25 for a longer period of time should cause a warning condition. The following figure shows the situation where the visual attention lowers for a few seconds.

The *Pulse rate analyzer* registers for the ox hemoglobin and deoxyhemoglobin level data streams. Since both signals contain a strong sinusoidal component related to heartbeat, the pulse rate can be calculated measuring the time delay between subsequent extremes of one of the signals

3. Data Logger Module

The module provides support for storing the monitored data in order to enable the supervisor to reconstruct and analyze the course of the operator's duty. The module registers as a consumer of the data to be stored in the database. Each working operator's data is recorded by a separate instance of the Data Logger.

4. Visualization Module

The module provides user interface for the supervisors. It enables them to watch each of the working operator's physiological condition along with a preview of selected video source and his related sound stream. All the incoming alarm messages are instantly signaled to the supervisor. Moreover, the visualization module can be set in the off-line mode, where all the data is fetched from the database.

The physiological data is presented using a set of custom-built GUI controls:

- a pie-chart used to present a percentage of time the operator was actively acquiring the visual information
- A VU-meter showing the present value of a parameter time series displaying a history of selected parameters' value

Types Of Users

Users belong to three categories:
•Operators
•Supervisors
• System administrators

Operator:

- Operator is a person whose physiological parameters are supervised.
- The operator wears the DAU.
- The only functions offers to the operator are Authorization to the system and receiving alarm alerts.
- Authorization: Operator has to enter his personal PIN into DAU, if PIN is accepted, authorization is said to be complete.
- Receiving Alerts: This function supplies the operator with the most important alerts about his and his co-workers' condition and mobile device state.

Supervisor:

- He is the person responsible for analyzing operators' condition and performance.
- The supervisor receives tools for inspecting present values of the parameters (on-line browsing) as well as browsing the results of the long-term analysis (off-line browsing).

System Administrator:

- He is the user that maintains the system.
- The administrator is delivered tools for adding new operators to the database. Defining alarm conditions.
- Configuring logging tools.
- Creating new analyzer modules.

Tools Used

During the implementation of the DAU there was a need of a piece of software to establish and test Bluetooth connections. Therefore a tool had been created called **BlueDentist** (Fig. 5). The tool provides support for controlling the currently connected Bluetooth device. Its functions are: local device management and connection management.

A simple tool was created for recording Jazz Multisensory measurements. The program reads the data using a parallel port and writes it to a file. To program the operator's personal ID card a standard parallel port is used, as the EEPROMs and the port are both TTL-compliant. A simple dialog-based application helps to accomplish the task. Using a relatively new brain sensing tool called functional near-infrared spectroscopy (fNIRS), along with a more established brain sensing tool called electroencephalography (EEG), we can detect signals within the brain that indicate various cognitive states.

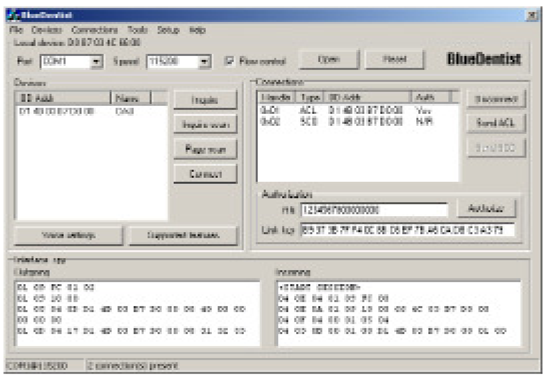


Fig. 5. Blue Dentist.

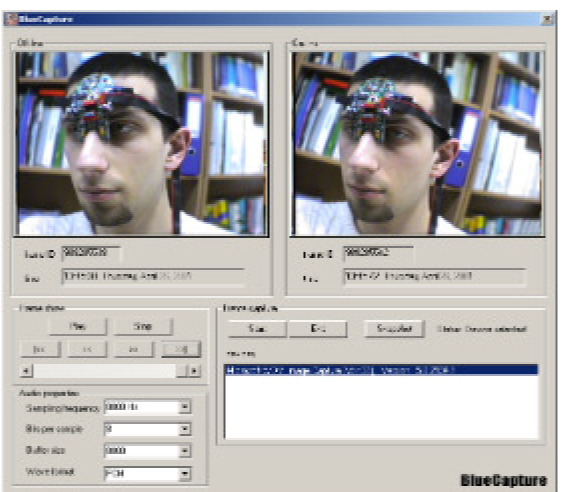


Fig. 6. Blue Capture.

These devices provide data on brain activity while remaining portable and non-invasive. The cognitive state information can be used as input to provide the user with a richer and more supportive environment, particularly in challenging or high workload situations such as management of unmanned aerial vehicles, driving, air traffic control, video games, health care, training, and anything involving information overload, interruptions or multitasking. It may also improve operation at the other end of the spectrum in highly automated systems that require little effort from the human, but that can result in boredom and low performance. In addition, while most of my research has focused on the broader population of healthy users, many of the results would benefit disabled users as well, by providing additional channels of communication in a lightweight manner.

Advantages

- Prevention from dangerous incidents
- Minimization of ecological consequences financial loss a threat to a human life

BlueEyes system provides technical means for monitoring and recording

- Human-operator's physiological condition. The key features of the system are:
- visual attention monitoring (eye motility analysis)
- physiological condition monitoring (pulse rate, blood oxygenation)
- operator's position detection (standing, lying)
- wireless data acquisition using Bluetooth technology
- real-time user-defined alarm triggering
- physiological data, operator's voice and overall view of the control
- room recording
- recorded data playback

BlueEyes system can be applied in every working environment requiring permanent operator's attention:

- at power plant control rooms
- at captain bridges
- at flight control centers

Data security - This system implies data security which is require in the modern network system.

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

Disadvantages

- Doesn't predict nor interfere with operator's thoughts.
- Cannot force directly the operator to work.

Applications

1. It can be used in the field of security & controlling, where the contribution of human operator required in whole time.

2. Engineers at IBM's office:smarttags Research Center in San Jose, CA, report that a number of large retailers have implemented surveillance systems that record and interpret customer movements, using software from Almaden's BlueEyes research project. BlueEyes is developing ways for computers to anticipate users' wants by gathering video data on eye movement and facial expression. Your gaze might rest on a Web site heading, for example, and that would prompt your computer to find similar links and to call them up in a new window. But the first practical use for the research turns out to be snooping on shoppers.

3. Another application would be in the automobile industry. By simply touching a computer input device such as a mouse, the computer system is designed to be able to determine a person's emotional state.

4. Current interfaces between computers and humans can present information vividly, but have no sense of whether that information is ever viewed or understood. In contrast, new real-time computer vision techniques for perceiving people allows us to create "Face-responsive Displays" and "Perceptive Environments", which can sense and respond to users that are viewing them. Using stereo-vision techniques, we are able to detect, track, and identify users robustly and in real time. This information can make spoken language interface more robust, by selecting the acoustic information from a visually-localized source. Environments can become aware of how many people are present, what activity is occuring, and therefore what display or messaging modalities are most appropriate to use in the current situation. The results of our research will allow the interface between computers and human users to become more natural and intuitive.

IV. FUTURE TREND

What can we do with blue eyes technology?

- It has the ability to gather information about you and interact with you through special techniques like facial recognition, speech recognition, etc.
- It can even understand your emotions at the touch of the mouse.
- It can verify your identity, feel your presence, and start interacting with you.
- The machine can understand what a user wants, where he is looking at, and even realize his physical or emotional states.
- It realizes the urgency of the situation through the mouse.
- For instance if you ask the computer to dial to your friend at his office, it understands the situation and establishes a connection.
- It can reconstruct the course of operator’s work.

V. CONCLUSION

BlueEyes need for a real-time monitoring system for a human operator. The approach is innovative since it helps supervise the operator not the process, as it is in presently available solutions. This system in its commercial release will help avoid potential threats resulting from human errors, such as weariness, oversight, tiredness or temporal indisposition.

In future it is possible to create a computer which can interact with us as we interact each other with the use of blue eye technology. It seems to be a fiction, but it will be the life lead by “BLUE EYES” in the very near future. Ordinary household devices -- such as televisions, refrigerators, and ovens -- may be able to do their jobs when we look at them and speak to them**.**

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