



# ThermoWEB-Remote Control and Measurement of Temperature over the Web

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## Abstract

*The remote control and measuring of temperature using the WEB (ThermoWEB) is based on an expansion of the measuring and operable usage possibilities of the thermovision camera NEC Thermo tracer TH7102WL. This camera's standard area for reading off temperatures is limited to one central point of the obtained thermal picture of the object. By using the additional programming support it is possible to choose any point inside the obtained thermographic picture of the object and get a quantitative and time-dependent value of temperature distribution. To the thermovision camera has been added a camera that registers the visible spectrum (CCD color camera), thus making it possible to accept pictures from the measured object in IR and in the visible spectrum. The camera system for measuring is controlled by a computer, which has a wireless or physical connection to the Internet. The result of these improvements is the realization of a high quality network system for remote and contactless measuring of temperature over the WEB.*

## INTRODUCTION

The infrared camera NEC Thermo tracer TH7102WL (1) (IR camera) represents a quality instrument for the contactless measurement of temperature. Its main deficiency is that temperatures can only be read off in a single central point of the obtained thermal picture of the object measured (Figure 1). Using the additional programming support it is possible to choose any point inside the obtained thermographic picture of the object and get a quantitative and time-dependent value of temperature distribution. The temperature value of any surface inside the thermographic picture can be represented in a numerical or graphical display. Besides the thermovision pictures recorded in the wave-length area of 8–14  $\mu\text{m}$  from the IR camera, the system has been extended with an additional color camera that operates in the visible part of the spectrum. The simultaneous display of pictures from both cameras provides additional possibilities of analysis of the observed object in the process of thermal inspection. Measured data can immediately be processed in real-time and displayed on a laptop screen or can be transferred to a remote location using the web connection, where processing and graphical visualization on the basis of an existing measuring database is performed.

A further limitation of the standard IR camera consists in the exclusive manual operation of the functions and controls of the IR camera (off-line mode). The obtained thermo picture of the object measured

can be stored on a compact flash memory card for later processing on a computer. Use of the existing IR camera's interface allows connection with a computer and, with suitable programming support, the management, control and transmission of data to the computer. The computer's next task is to process, visualize and distribute the data obtained to the remote location over the WEB.

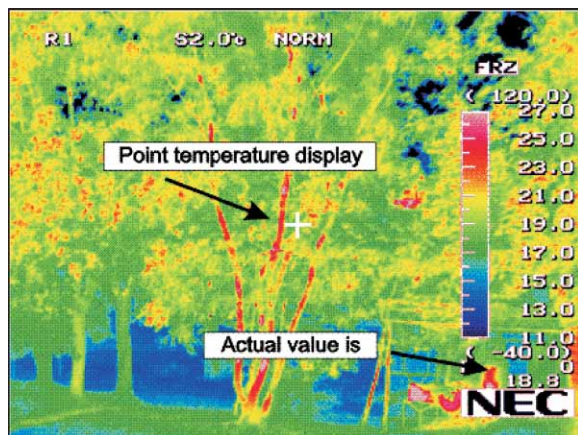


Figure 1. Data display of Thermo tracer TH7102WL.

The above-mentioned software and hardware expansions of the standard thermovision camera NEC Thermo tracer TH7102WL have resulted in a measuring device with wide areas of usage for contactless measurements or temperature control which can be used independently and/or remotely using WEB surveillance.

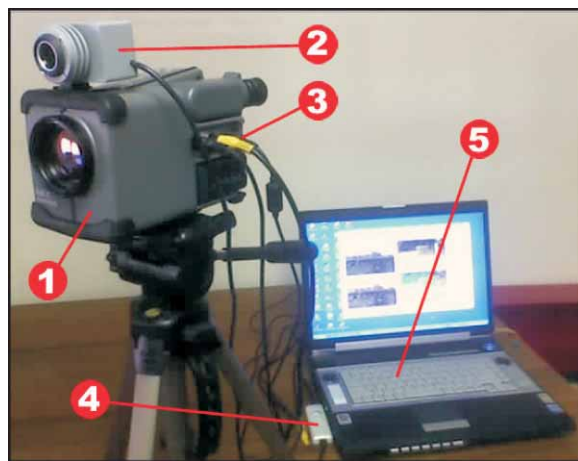


Figure 2. Components of the ThermoWEB system.

## ThermoWEB SYSTEM

The Thermo WEB measuring system (Figure 2) (2) comprises a thermovision camera NEC Thermo tracer TH7102WL (1), with the following functional components added:

- Electromechanical components of the measuring system (Hardware components),
- Software support.

## Hardware components of the measuring system

The hardware component of the measuring system includes a video CCD color camera (640x480 pixels) (2), set in an appropriately shaped housing (IP54), with a mechanical adapter for assembly onto the housing of the IR camera, and a circuit for choosing and accepting video signals (4) from the camera to the computer (USB2) (5).

Operation of the functions of the IR camera is done by using a computer with RS232 interface (3).

## Software support for controlling and measuring

The software support for the measuring system comprises of:

- main menu of the ThermoWEB system,
- ThermoCAM control, software support for control of the IR camera (TH7102WL),
- ThermoWORK, software support for measuring of temperature and
- Software support for remote control and data viewing over the WEB.

## Main menu

The main menu of the ThermoWEB system (Figure 3.) appears on the computer screen during the finishing stage of the ThermoWEB software installation, and it is used for calling all other subprograms that are used in the procedure of system controlling and measuring. If the system computer is connected to the network, at the same time as the main menu, an internet explorer will appear and connect to a predefined WEB address, where the ThermoWEB instruction manual (help) or some other useful content issued by the software support provider can be found.

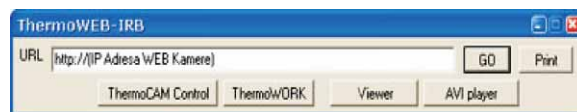


Figure 3. Main menu.

The following program groups can be called from the ThermoWEB main menu:

- Software support for controlling the IR and video cameras-*ThermoCAM control*,
- Software support for contactless measurements of temperature-*ThermoWORK*,
- Image viewer- *Viewer*,
- Movie viewer-*AVI player*,
- Software support for remote data viewing.

## Software support for IR camera control- ThermoCAM

The software support the ThermoCAM (Figure 4), connects the IR camera with the computer through a RS323 interface, thus allowing control with all existing input/output functions and controls of the IR camera (č150 different settings), as follows:

- Camera parameters (date, time, temperature units, colour range display, etc.),
- Parameters for compensation of environmental conditions (calibration) and work control settings (status bar),
- Work mode (run/freeze/auto),
- Temperature range, measuring range and sensitivity threshold,
- Saving of thermographic images of the measured object on the computer's external memory (SD card) (off-line processing),
- Change of IR camera focus,
- Choosing of the colour range (colour bar) in which the image will be presented and the presentation of data on the IR camera screen,
- Rest of the setting shown on picture (Figure 4),
- Setting menu for connecting with a computer through RS323 protocol (Figure 5).

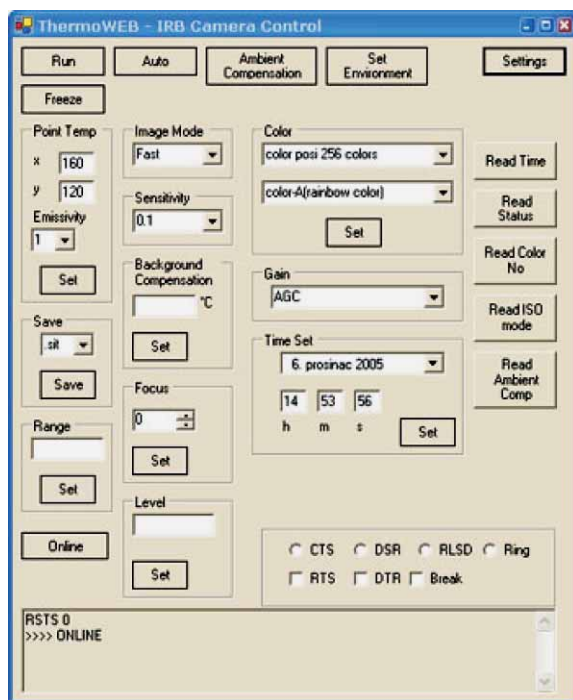


Figure 4. Software support for IR camera control- ThermoCAM.

The programming support has the task of choosing and accepting video signals from the cameras, processing the collected information and giving a numerical-gra-

phic presentation on a computer screen. All data and results shown on the connected (on-line) computer are at the same time sent over the web connection to a chosen location on the computer network (WEB), or in other words, the acceptance of command-control orders via the web is performed.

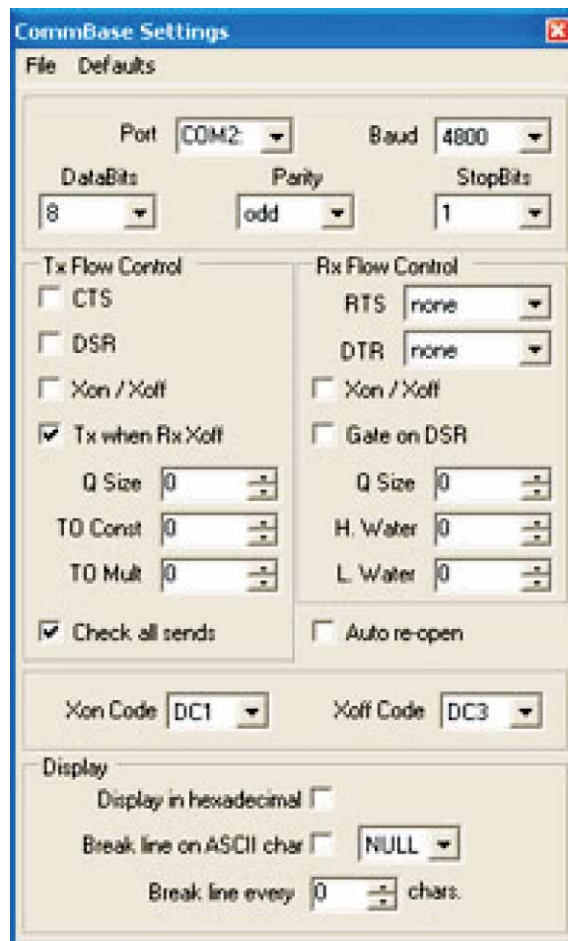


Figure 5. Setting menu for RS232 protocol.

## Software support for measuring-ThermoWORK

The measuring of temperature, in certain points of the measured object, is done by the ThermoWORK program (Figure 6).

The programming support for accepting video signals from the cameras shows two pictures simultaneously on screen or on two separate screens of the connected computer (optional) (Figure 6, windows 1. and 2.). Because of the difference in resolution between the thermovision (320x240) and video (640x480) cameras, which cover approximately the same field of vision, the picture from the video camera is more acceptable for recognition of details of the object measured than the thermographic display, whether color or mono, obtained with the IR camera. The thermographic display of the object measured is given in 256 levels of temperature intensity in-



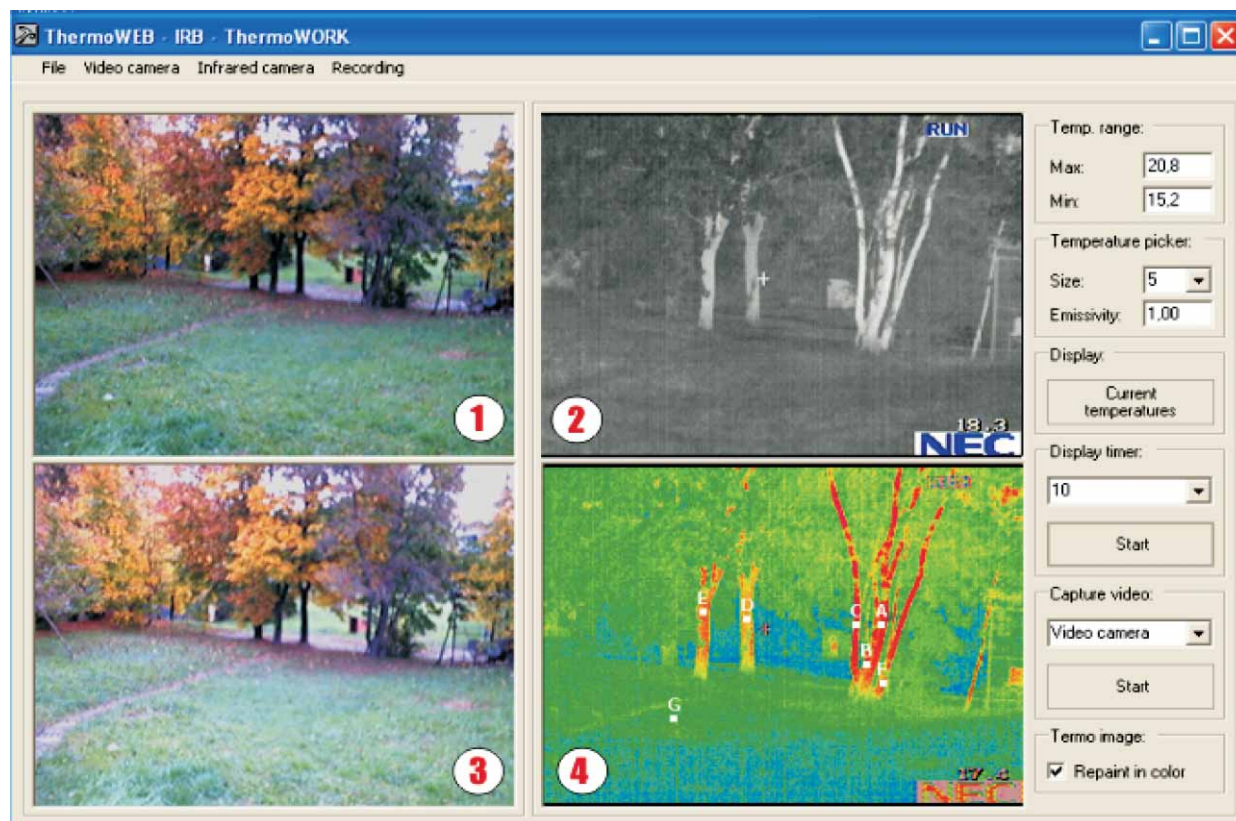


Figure 6. Main screen of ThermoWORK.

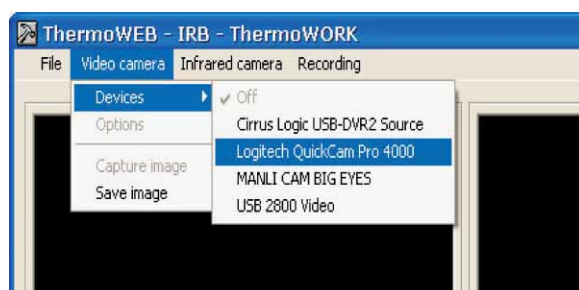


Figure 7. Selecting the cameras.

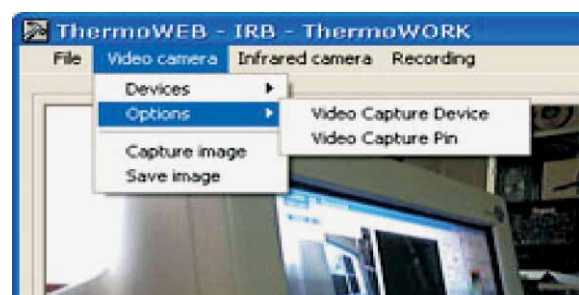


Figure 8. Settings for the video camera.

side the chosen measuring area (color or black-and-white intensity wedge), with one numerical value for the measuring area in the middle of the picture indicated with a marker.

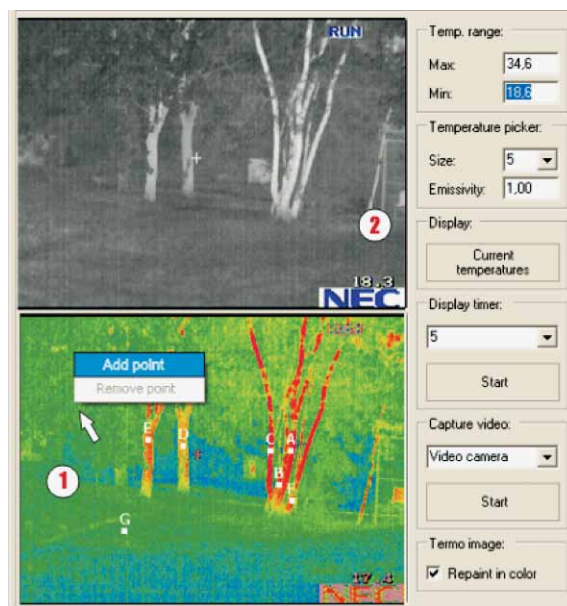


Figure 9. Adding the measuring temperature points.

Input video signals from the cameras are chosen in the *Video camera* and *Infrared camera* menus (Figure 7). Here all the necessary settings for the video camera can also be made (Figure 8).

An image from the cameras (Figure 6, windows 1. and 2.) can be frozen by choosing the *Capture Image* option from

the *Video camera* and *Infrared camera* menu. Still images are shown on the screen (Figure 6, windows 3. and 4.).



Figure 10. Removing the measuring temperature points.

Measuring temperature points can be added (Figure 9) and removed (Figure 10) to the image obtained from the IR camera. Size (from 1 to 961 pixels) and emissivity properties (from 0,00 to 1) can be modified for each measuring point. The max. number of measuring points is not predefined, so it can be set by the user.

If the *Current temperature* (Figure 9.) option from the toolbar on the right side is chosen, the application will show the current temperatures at the measuring points. For periodical temperature measuring the *Display timer* option is used. The time interval has to be set (1 to 600 seconds) and then the function is executed by pressing start. The application then periodically measures the temperature, and the measured values will then be shown in the table (Figure 11). The results can be stored in a text file or can be graphically shown on the screen (Figure 12).

The extraction procedure for information about temperature values on the basis of the intensity of each point of the thermographic picture is given in references (3). By moving the marker along the picture, as demonstrated in Figure 9 and Figure 10, it is possible to read off the temperature values for any place inside the picture. Besides the momentary read-off of temperature values for single measuring points, it is possible to memorize the

| ThermoWEB - IRB - ThermoWORK - Temperature data |          |                 |                 |                 |                 |                 |                 |                |
|---|----------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|----------------|
| Export data                                     |          | Create a graph  |                 |                 |                 |                 |                 |                |
|   | Time     | A (225, 112, 1) | B (215, 140, 1) | C (208, 112, 1) | D (135, 108, 1) | E (106, 103, 1) | F (226, 153, 1) | G (86, 178, 1) |
| ▶   | 16:25:12 | 19,7            | 19,6            | 20,3            | 18,8            | 19,3            | 19,7            | 17,6           |
|   | 16:25:22 | 19,5            | 19,5            | 20,2            | 19              | 19,3            | 19,6            | 17,1           |
|   | 16:25:33 | 19,5            | 19,5            | 20,1            | 18,8            | 19,2            | 19,5            | 17,1           |
|   | 16:25:42 | 19,6            | 19,7            | 20,2            | 18,7            | 19,2            | 19,8            | 17,4           |
|   | 16:25:52 | 19,5            | 19,7            | 20,2            | 18,8            | 19,2            | 19,6            | 17,4           |
|   | 16:26:02 | 19,7            | 19,7            | 20              | 19              | 19              | 19,7            | 17,6           |
|   | 16:26:12 | 19,6            | 19,6            | 20,3            | 18,8            | 19,2            | 19,6            | 17,4           |
|   | 16:26:22 | 19,6            | 19,7            | 20,1            | 18,8            | 19,2            | 19,9            | 17,4           |
|   | 16:26:33 | 19,6            | 19,7            | 20,2            | 18,8            | 19              | 19,8            | 17,5           |
|   | 16:26:42 | 19,6            | 19,6            | 19,9            | 19,1            | 19,3            | 19,6            | 17,3           |
|   | 16:26:52 | 19,6            | 19,9            | 20,1            | 19,2            | 19,4            | 19,5            | 17,2           |
|   | 16:27:02 | 19,6            | 19,7            | 20,1            | 19,3            | 19,4            | 19,8            | 17,4           |
|   | 16:27:12 | 19,9            | 19,7            | 20,1            | 19              | 19,5            | 19,7            | 17,3           |

Figure 11. The measured values of temperatures.

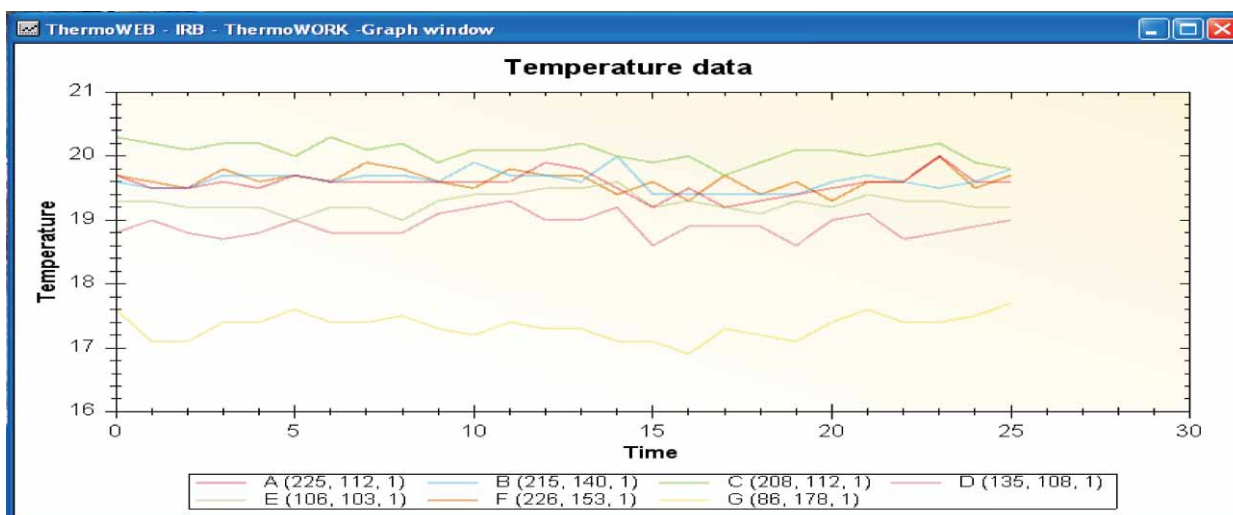


Figure 12. Graph window.



points where there is a need for continuous tracking of temperature changes over a period of time. It is possible to assign a coefficient of emissivity  $\epsilon$  to each point chosen for reading off temperature values.

A display of 3D temperature information is given in a specially opened window, with the images from both cameras retained. The numerical value of temperature distribution of the measured object is given on the  $z$  (16, 32, 64, 128 or 256 level) axes, where the  $xy$  plane (320x240) represents measuring points on the object (optional) (4).

Besides images, the ThermoWork application can also store video recordings. To store videos, the *Capture video* option from the toolbar on the right has to be selected.

The temperature measurement procedure can be performed on one picture only (single frame-mode freeze) or it can continually monitor the time dependence of changes in temperature intensity of a point or surface by taking pictures with a max. frequency of 60 Hz. The continued time-tracking of temperature intensity makes it possible to determine the frequency change of a single thermal surface inside the picture, which results in the possibility of differentiating single optic outdoor sources (5).

Analogously to the procedure described, the process can be applied fully on data from the external memory (compact flash memory card-CFM) of the thermovision camera, when used without a computer (off-line).

### Image viewer

The image viewer (Figure 13.) allows you to view images (.BMP, .JPG, .GIF format) from the external memory (CFM card) IR camera or images stored by the user from the video or IR camera during the measuring.

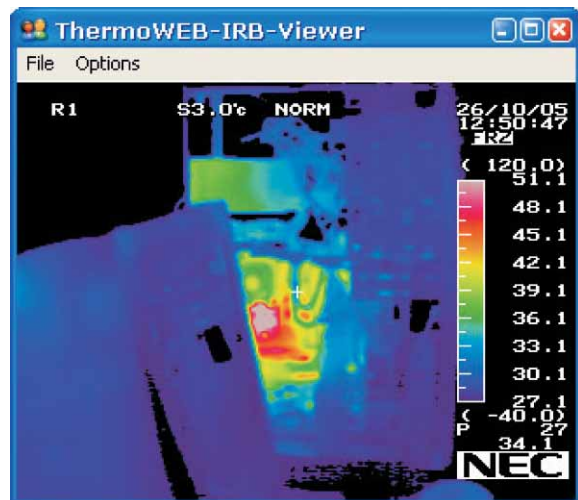


Figure 13. Image viewer.

### AVI video player

The ThermoWEB system also includes a video player for AVI format (Figure 14).



Figure 14. AVI player.

## Software support for remote control and data viewing over the WEB

The ThermoWEB software support allows a dislocated computer to, through a net connection, take over all the ThermoWEB system functions or just to view measured data, as well as video and images from the IR and video camera during the measuring procedure.

### Software support for remote control

The ThermoWEB system can be remotely controlled from a dislocated computer using the Remote Desktop application, which is built in the Windows operation system. It is enough just to start the application and choose the computer which has the ThermoWEB software support installed. After the connection has been established, the user can control all the ThermoWEB system functions.

ThermoWEB has also been tested with some other remote control applications and has been found completely stable, so it is not necessary to use the MS Remote Desktop exclusively.

### Software support for remote data viewing

Because connecting through the Remote Desktop application requires large network bandwidth, the ThermoWEB system has a built in option for viewing measured data through the http protocol, with simultaneous showing of image from video or infrared cameras (Figure 15, windows 1. and 2.). To view data it is enough just to enter the IP address of the ThermoWEB provider into the main system of ThermoWEB, so that the remote computer instructions menu will appear in the ThermoWEB internet explorer. The procedure requires both computers (user and remote) to have the ThermoWEB software support installed.

## CONCLUSION

The results achieved through the concept of the ThermoWEB system described can be summed up in the following points:

Visualization of measurement data and processing results has been obtained,

- A WEB measuring system in LAB WLAN surroundings (WEB measurements instrument) has been achieved,

- A distributed measuring system in the infrared wavelength area with the appropriate functionality across the network has been realized,

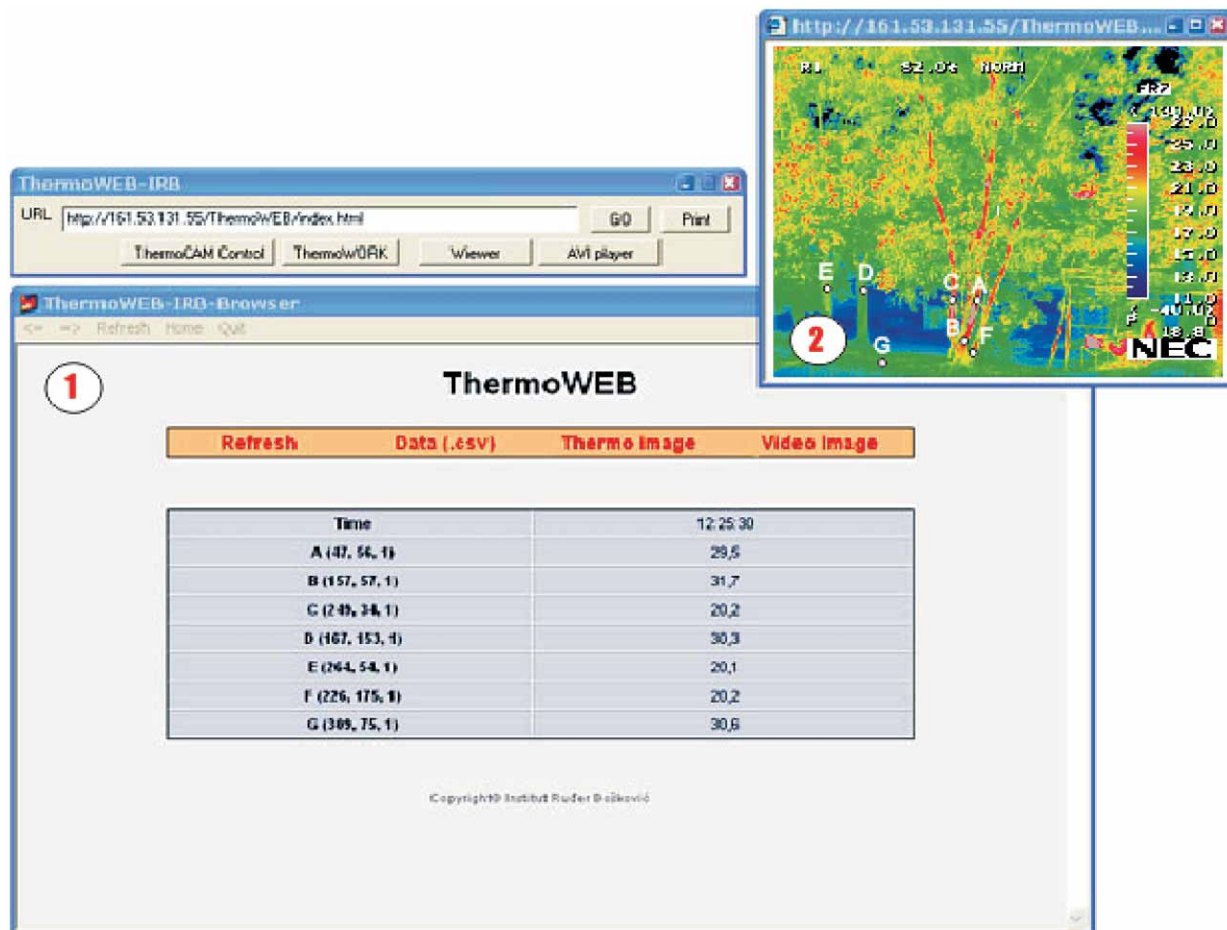


Figure 15. Screen for remote data viewing.

- Long-distance thermovision inspection has been made possible with the aid of contemporary technical measuring and web-communication technologies,
- The system concept has been opened for new possibilities of application.

Potential Thermo WEB users are scientific institutes, as well as economic entities, where a need exists for independent and/or collective remote temperature measuring and control (thermographic inspection); likewise in the areas of ecology, construction, medicine, electrical distribution, thermal-nets, electro-techniques, computer sciences, etc.

A particularly important area of use of the ThermoWEB is in the process of early detection of forest fires through web measuring systems distributed in special protected areas (6–9).

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