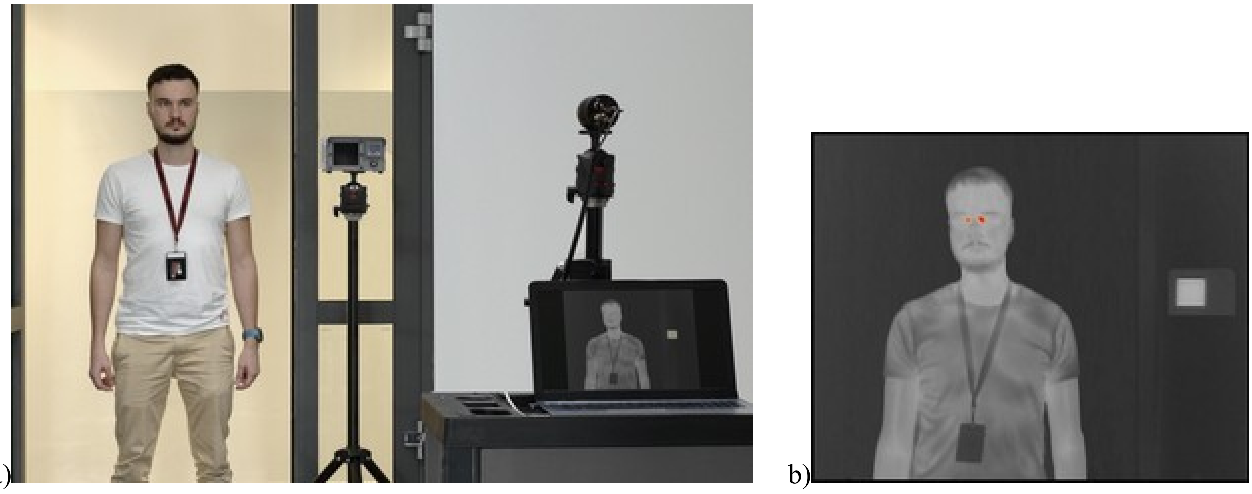
TREEN

Thermograph for human febrile temperature screening



a) b)

Fig.1. TREEN a)photo of thermograph system, b)thermal image of tested human

1 Basic information

TREEN is a high performance thermographic system for human febrile temperature screening that can be built using typical off shelf portable surveillance thermal imagers. It is expected to be used as a tool to detect potentially infectious individuals having fever symptoms caused by coronavirus. TREEN is a technology developed by Inframet and offered to manufacturers of military type portable surveillance thermal imagers that makes possible rapid modernization of already manufactured surveillance thermal imagers into professional fever screening thermographs. In detail, Inframet does not offer sale of complete thermographs for human febrile temperature screening but offers sales of know how to modernize surveillance thermal imagers to professional professional fever screening thermographs for prevention of fever-producing infectious diseases like coronovirus.

2 How TREEN is built and works?

TREEN is a system optimized for fever screening humans passing through narrow gates by non contact measurement and analysis of temperature distribution on face of these humans. It is built by combining a typical portable surveillance thermal imager with four additional blocks: external blackbody, laptop, frame grabber, and test software. The blackbody is located at gate plane and works as a reference source of thermal radiation. Laptop is used as computing system and platform for control/test software. Frame grabber enables capturing of video images generated by the thermal imager. Test software enables image processing of captured video images and determines if tested human is febrile. These additional blocks are to be delivered by Inframet.

3 Medical basics

Ability for fast, non contact and precision detection of humans having high temperature of body core is critical detecting febrile humans and prevention of fever-producing infectious diseases like coronovirus.
On the basis of experience with SARS epidemic it is typical that a person having body core temperature 38ºC or above is considered as febrile and should be treated as potentially infected. It should be noted that this level of alarm is only 1ºC higher over temperature of average perfectly healthy person. Healthy persons of increased metabolism or more agitated having temperature as high as 37.5ºC can occur too. Therefore, precision detection of febrile humans is a challenge.

Classical contact methods of measuring body core temperature (measurement of rectal temperature and oesophageal temperature) cannot be used due to too slow test speed and risk of infection caused by direct contact with the thermometer. Therefore non-contact methods are needed to determine temperature of human body core on basis of measured temperature of some external body parts. Medical experiments have shown that temperature of the inner canthus is best correlated with temperature of body core and such measurement is recommended by both standards and scientific papers devoted to fever screening. However, non contact measurement of temperature of the inner canthus is difficult due to small size of this part of human body. Therefore measurement of temperature of human forehead is often used but this temperature is not well correlated with temperature of body core and additionally varies strongly on environment conditions.

4 Market situation

Market for fever screening devices is dominated by low cost non contact infrared thermometers used for measurement of forehead temperature. Low price is a big advantage of these devices but their practical efficiency is low. Alarm temperature threshold must be set high in order to avoid high number of false alarms caused by high temperature measurement error (±1ºC for typical units) and variability of forehead temperature depending on environment conditions. In addition test procedure is slow and generates infection risk for test team due to short distance to tested persons.

Measurement thermal cameras offer much higher potential due to ability to generate detail image of human face from safe distance of several meters at a fraction of a second. These cameras used for fever screening can be divided into three groups: 1) general purpose measurement thermal cameras, 2) measurement thermal cameras for research applications, 3) fever screening thermographs. It should be noted that all these imaging systems are advertised as tools for fever screening.

Manufacturers of general purpose measurement thermal cameras typically declare in data sheets temperature measurement accuracy/stability at level ±2ºC. Practically it means that these cameras are almost useless for fever screening application due to too low accuracy/stability. In spite of very limited effectiveness of these cameras, some unscrupulous distributors are taking advantage of the high demand to sell such thermal cameras designed for industrial use as fever screening medical tools.

Research grade measurement thermal cameras of typical measurement accuracy/stability at level ±1ºC offer higher potential as fever screening tools. However, accuracy/stability is still too poor to achieve high fever test sensitivity (test result is positive for febrile person having increased temperature) and specificity (test result is negative for non febrile person having normal temperature of body core).

High sensitivity/specificity of fever screening tests can be achieved only when using the third group of measurement thermal cameras called in professional literature as fever screening thermographs.

The screening thermographs (different names related to fever detection are also used in literature) are basically typical measurement thermal cameras with additional blackbody located in camera FOV in order to increase accuracy of measurement of temperature distribution on faces of tested humans. Use of external reference blackbody in camera FOV enables to achieve significantly better accuracy of temperature distribution on human face (level of ±0.3ºC is often declared in data sheet) comparing to typical measurement thermal cameras. However, there is still a number of challenges and real accuracy offered by screening thermographs offered on the market is often several times worse.

First, the inner canthus is a small part of human face and accurate measurement of its temperature is possible only when using high resolution thermal cameras having pixels many times smaller. Therefore IEC 80601-2-59 standard ((IEC 80601-2-59:2017 Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening) recommends that pixel size of target plane should not be bigger than 1 mm. If this recommendation is not met then measured temperature of the inner canthus will be significantly lower comparing to real temperature. Next, the same standard presents a set of additional requirements on uncertainty of external temperature reference source, temporal drift, non-uniformity in FOV, non-stability and minimum resolvable temperature difference of the screening thermograph. However, market reality is that majority of screening thermographs available commercially do not fulfill event these requirements or/and are used incorrectly. There are numerous scientific papers that show poor performance of commercial screening thermographs due to their limited technical specifications or incorrect use. It looks also that some manufacturers of screening thermographs are not even aware that there are standards that give recommendations on design and use of these measuring systems. However, due to huge demand for screening thermographs due to coronavirus pandemic even low performance screening thermographs are sold but their use generate only psychological effect on general public not real protection against coronavirus.

5 Why TREEN thermographs?

TREEN technology is based on many years of Inframet experience in production of systems for testing thermal imagers (including thermal imagers used for SARS prevention), design of thermal camera cores for internal use, and participation in scientific projects to develop ultra high accuracy measurement thermal camera for medical applications. On basis of such know how Inframet has developed a screening thermographs that exceed requirements of the IEC/ISO standard on fever screening thermographs. TREEN offers also better technical parameters that are not listed in the standard but are still extremely important (Table 1).

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Table 1. Comparison of specifications of TREEN screening thermograph versus requirements of IEC 80601-2-59 standard and parameters of typical screening thermographs

Parameter	Standard uncertainty (IEC 80601-2-59)	Typical screening thermograph	TREEN
Temperature resolution of the reference blackbody	-	0.1ºC	0.01ºC
Standard uncertainty of of the reference blackbody	0.15ºC	±0.2ºC (accuracy)	0.05ºC
Blackbody emissivity	0.98 (skin emissivity)	0.97±0.02	0.98±0.005
Blackbody temporal stability		±0.1ºC	±0.03ºC
System performance			
Image resolution [px]	320x240	Sometimes below 320x240	At least 320x240
Max pixel size at target plane	1mm	>2mm	<1mm
Display temperature resolution	0.1ºC	0.1ºC	0.05ºC
Target plane resolution	320x240		At least 320x240
Temperature range	From 30ºC to 40ºC		
Temporal drift	0.06ºC	>0.1ºC	≤0.05ºC
Spatial measurement non uniformity	0.06ºC	>0.13ºC	≤0.05ºC
Instability	0.06ºC	>0.1ºC	≤0.03ºC

Modular design based on typical surveillance thermal imager as the main block is another main difference of TREEN comparing to typical specialized screening thermographs offered on the market. It means that TREEN thermographs can be built in short time using surveillance thermal imagers already manufactured and in manufacturing process. It means also that if TREEN screening thermographs are not longer needed (epidemic of infectious diseases is finished) then the surveillance thermal imager can be used for its original application.

6 Recommendations on surveillance thermal imagers to be modernized

Inframet can modernize virtually all surveillance thermal imagers for TREEN thermographs. However, due to economical and technical reasons there are some preferences on surveillance imagers to be modernized:

1. type: portable non cooled
2. spectral band: 8-14 µm
3. video output: analog video (option: Ethernet, USB 2.0/3.0)
4. image resolution: at least 320x 240 pixels
5. focal length of IR objective: from 20mm to 60mm

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