Medical applications of thermal imaging

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Content

• Introduction to thermal imaging
• Different medical applications of thermal imaging
• Ongoing research within the MIPT research unit:
  – Temporomandibular disorders
  – Knee osteoarthritis
• Conclusion
Infrared thermal imaging

Source: 2011 HowStuffWorks
Interests

• Cost of thermal imaging hardware is dropping
• New hardware compatible with smartphones are being developed
• The resolution of the devices increases
• Non-invasive

Many applications: electronics, security, construction, veterinary, medical...
Thermal imaging – some applications

Screening in airports for people with fever:
- Severe acute respiratory syndromes
- H1N1
- Ebola
...

Detection of abnormally low temperature

- Tissue necrosis
- Reduced Blood flow
- Teeth health

Too tight bandage

Loosening the bandage to restore the blood flow

Bad teeth with damaged nerve tissue

Mari Vainionpää: «Thermographic Imaging in Cats and Dogs usability as a Clinical Method» (PhD thesis)
Inflammation and infections

- Inflammation has become one of the “hottest” areas of medical research
- 1/3 of all cancers are caused by chronic inflammation (University of California)
- Chronic inflammation underlies health issues not being addressed
- In most cases, the patients are not aware that they are inflamed, which is a real risk.
Pain

• Assessing pain subjectively could improve the information provided to the practitioners

• Activity of muscles can be representative of pain:
  – Activity of facial muscles related to emotions
  – Decrease of muscle activity due to pain

Atrophy of the right calf muscle
http://www.integrativelifesolutions.com/
Breast cancer

• Tumors are warmer than surrounding tissue, as they have an increased blood supply.

• thermography can differentiate underlying malignancies, infections or pre-cancerous inflammation from benign cysts (cooler), that appear similar in mammograms.

Thyroid Eye Disease

• Related to Grave’s disease: autoimmune disease that affects the thyroid, ¼ cases will develop it
• Eye problems with bulging, redness and swelling of the eyes, grittiness, soreness and pain, double vision and even blindness
• Can help early diagnostic

Source: T. C. Chang et al.
Rehabilitation

Before RegentK

After RegentK

G. Litscher et al., 2014

Regentk = pressure therapy
Affective states - Psychophysiology

- Human emotions
- Depression
- Arousal
- Stress
- Joy
- ...

Thermal representation for extraction of ROIs along with a vascular representation of the major vessels affecting the subcutaneous temperature of the face (Berkovitz et al., 2013)
Material

Thermal camera Flir T420:
- Resolution: 320 x 240
- Thermal sensitivity: <0.045°C
- Spectral range: 7.5 to 13μm

Infrared Thermometer - MLX90614:
- Non-contact
- Thermal sensitivity: 0.02°C
- Cheap (20 $)
Temporomandibular disorders:
Pilot clinical trial (N=40: controls 20, TMD 20)

Protocol:
• Clinical examination
• Pain questionnaires
• Cone-beam CT imaging
• MRI
• Thermal acquisition
  - Relax (30min in ambient temperature)
  - After chewing 4 min
  - After chewing 8 min

http://thescienceofdentistry.com/
Image processing

Calculated parameters:
- Min / max / average temperature
- Entropy
- homogeneity
Preliminary results

- Males ≠ Females
- Difference before and after chewing for 4 minutes is the most relevant
- The fat alters the results

N=66

N=14

Patient with the disease

Healthy patient

Pain vs temperature
Knee osteoarthritis:
Clinical trial (N=109: controls 57 / OA:52)

- Medical examination + BMI + pain reports
- MRI + X-ray
- Thermal imaging
- Thermal sensors acquisition
- Walk on threadmill
- Thermal imaging
- Thermal sensors acquisition
Example of thermal images

Healthy knee

Severe OA
Thermal imaging vs thermal sensor

Pearson correlations:
- Patella: $R = 0.866 – 0.885$
- Lateral: $R = 0.897 – 0.920$
- Medial: $R = 0.847 – 0.872$
Preliminary results

Thermal sensors vs. MRI effusion (N=65, Females)

- Males ≠ Females
- Model: temperature difference between sensors before and after walk + BMI
- Half of the data was used to train the model and the remaining to validate + vice versa (N=65)

ROC Curve

AUC: 0.74
Conclusion

- The method can provide information on some specific conditions
- It could provide tools to quantify inflammation / pain
- The hardware cost has drastically reduced the past few years
- Standardized method for thermal acquisition is lacking

→ An emergence of new thermal imaging applications can be expected