Surface Analyzer TiVi95
User Manual

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PIONEERS IN TISSUE VIABILITY IMAGING
Dear Valued Customer!

Welcome to the WheelsBridge TiVi95 Skin Surface Analyzer system intended for automatic analysis of cellulite appearance. The TiVi95 Skin Surface Analyzer was designed especially for observer-independent analysis of cellulite in association with evaluation of skin care products and follow up of treatment regimes.

The TiVi95 Skin Surface Analyzer utilizes a highly sensitive digital camera equipped with polarization filters making it possible to suppress direct surface reflections from the skin surface. The versatile system software – based on the MATLAB® high performance language for technical computing – allows for rapid and easy capturing and analysis of images. Among the many useful features of the TiVi95 Skin Surface Analyzer software the following are of particular interest:

- Automatic capturing of photos.
- Region of Interest analysis.
- Automatic tracking of cellulite dimples.
- Library function to display up to 6 photos simultaneously.
- Trend monitoring.
- Surface Reflection Analysis

We are convinced that the Surface Analyzer TiVi95 will be a productive tool in the assessment and follow-up of cellulite appearance following treatment with skin care products.

Thank you for choosing the WheelsBridge TiVi95 Skin Surface Analyzer.

WheelsBridge AB
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The Surface nalyzer is not registered as a Medical Device. It is intended for research applications only.

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1. INTRODUCTION

Most women and some men show signs of cellulite where the skin of the lower limbs, abdomen and the pelvic region becomes dimpled. The causes of cellulite are not fully understood, but hormonal components are thought to play a dominant role in its formation. Several genetic factors promote the development of cellulite as do lifestyle factors. A number of therapies for treatment of cellulite are available, but empirical evidence of the efficacy of these treatment regimes is limited, mainly due to lack of methods for quantification of cellulite appearance. The TiVi95 Skin Surface Analyzer is a software package that analysis important features of cellulite and associated skin dimples based on photos captured by polarization spectroscopy camera technology.

The intended use of the TiVi95 Skin Surface Analyzer is to analyse the appearance of cellulite in laboratory applications. It is not yet approved for the diagnosis and treatment of cellulite.

2. OPERATING PRINCIPLE

The TiVi95 Skin Surface Analyzer operates in the following way:

1. Photos of the actual skin area are captured before and after treatment.
2. These photos are uploaded to the TiVi95 Skin Surface Analyzer main window.
3. Regions of interest (ROI) are drawn around the cellulite area.
4. When the ROIs are displayed, the average intensities of the two photos are equalized.
5. Tracking of skin dimples starts automatically and analysis of local irregularities in intensity of the two photos are performed.
6. The cellulite areas are displayed in grayscale superimposed on the photos.
7. An Improvement Index is calculated to quantify the result of the treatment.
8. Up to six photos with superimposed cellulite areas can be displayed and compared in the Library window.
9. In the Trend Analyzer changes in Improvement Index of the six photos are displayed.
10. All basic recorded and calculated data can be stored in a MS Excel ® spread-sheet.
3. CELLULITE PARAMETERS

The TiVi95 Skin Surface Analyzer automatically tracks areas with low and irregular intensities associated with skin dimpling. In the Reference photo (generally the photo captured before treatment) the cellulite areas are displayed in grayscale while the non-cellulite areas are displayed in colour. As default the threshold value in the Reference photo is set in such a way that 50% of the photo displays grayscale values (Sensitivity = 1).

In the Second photo (generally the photo captured after treatment) the average intensity is first made identical to that in the Reference photo. Applying the same threshold as in the Reference photo the cellulite areas in the Second photo can now be displayed in grayscale.

The Improvement Index when going from the Reference photo to the Second photo is calculated according to:

\[
\text{Improvement Index} = 1 - \frac{\text{Relative grayscale area in Second photo}}{\text{Relative grayscale area in Reference photo}}
\]

When the relative grayscale area in the Second photo is zero, the Improvement Index = 1 (maximal improvement) and when the relative grayscale area in the Second photo is identical to that of the Reference photo, the Improvement Index = 0 (no improvement).
In the **GETTING STARTED** section these and other features are further explained by way of an example.

## 3. GETTING STARTED

The basic features of the *TiVi95 Skin Surface Analyzer* are probably best explained by way of an example. In the following example it is assumed that the photos *Before-0001.jpg* and *After-0001.jpg* have been captured by a camera with polarizing filters and stored in the *TiVi95demonstration* folder. These photos demonstrate cellulite appearance before and after treatment at somewhat different exposure. The task is to calculate the **Improvement Index** for the actual treatment procedure.

1. Open the *TiVi95 Skin Surface Analyzer* main window.

   ![TiVi95 Surface Analyzer window](image)

2. Click **Load Photo1** and navigate to the *TiVi95demonstration* folder. Double-click the *Before-0001* file. The *TiVi95 Surface Analyzer* window should now look like.

   ![TiVi95 Surface Analyzer window](image)
3. Click the **Load Photo 2** button and double-click the *After-0001* file. The *TiVi95 Skin Surface Analyzer* window should now look like:
4. Draw a Region of Interest (ROI) by placing the mouse courser at the upper left corner of the ROI, pressing the left mouse button and dragging the mouse to a point representing the lower right corner of the ROI, where the left mouse button is released. The TiVi95 Skin Surface Analyzer window should now look like:

5. Draw a similar ROI over approximately the same region in Photo 2.
6. Click the **Show ROI 1** and then the **Show ROI 2** button. The cellulite areas in the two photos are now displayed in grayscale and the **Improvement Index** is calculated to 0.98.
7. Click the **Display Photo 1** and **Display Photo 2** button to display the original ROI areas without the cellulite areas superimposed.

8. Click the **Display Mixed 1** and **Display Mixed 2** button to display the original ROI areas with the cellulite areas superimposed.

9. Click the **Save ROI 1** button to save the ROI 1 photo. Insert “A” in the Filename edit box and click the **Save** button. The ROI 1 is now saved under the name *Cell_A_Before-0001*. Files with prefix *Cell* can be read into the **Library**.

10. Click the **Library** button to open the empty **Library** window.

11. Click **Load photos** to open the **Pick a file** window. Navigate to the *TiVi95demonstration* folder and select *Cell_A_ce-0001* to *Cell_A_ce-0005* by first clicking on the *Cell_A_ce-0001*, then pressing the **shift** button on the computer keyboard, while the *Cell_A_ce-0005* file is selected. Alternatively individual files can be selected while pressing the **Ctr** button on the computer key-board, while clicking on the actual file name.

12. Click the **Open** button. The **Library** window should now look like:
13. The **Library** window now shows five photos captured at different points in time during a treatment procedure. The gray areas represent the skin sites classified as cellulite areas and the **Improvement Index** (in red) reflects the improvement as the extension of the gray areas successively diminishes.

14. Click the **Trend** Button to display the **Improvement Index** trend.
15. Click the **Export** button to save the **Improvement Index** sequence to an MS Excel ® spread-sheet.

This concludes the **GETTING STARTED** session.
4. DETAILED DESCRIPTION

4.1 Surface Analyzer TiVi95 Main window

When the TiVi95 Skin Surface Analyzer is started in tool-box mode from inside the TiVi700 Analyzer, the TiVi95 Skin Surface Analyzer main window is displayed.

1. **Load Photo 1** – to load a new photo and display it in the Photo1 frame.

2. **Show ROI 1** – to show the ROI drawn in the Photo1 frame photo.

3. **Save ROI 1** – to save the ROI under a specific name. When the “name” is inserted in the Save as window **File Name** edit box. The complete name of the file will be “Cell_name_oldname”. Only photos with the prefix “Cell” can be uploaded into the TiVi95 Surface Library window.

4. **Display Photo 1** – to display the photo only.

5. **Display Mixed 1** – to display the cellulite area superimposed on photo.

6. **Name** – shows the name of the photo displayed in the Photo1 frame.
7. **Date** – shows the date at which the photo displayed in the **Photo 1** frame was captured.

8. **Load Photo 2** – to load a new photo and display it in the **Photo 2** frame.

9. **Show ROI 2** – to show the ROI drawn in the **Photo 2** frame photo.

10. **Save ROI 2** – to save the ROI under a specific name. When the “name” is inserted in the **Save as** window **File Name** edit box. The complete name of the file will be “Cell_name_oldname”. Only photos with the prefix “Cell” can be uploaded into the **TiVi95 Surface Library** window.

11. **Display Photo 2** – to display the photo only.

12. **Display Mixed 2** – to display the cellulite area superimposed on photo.

13. **Name** – shows the name of the photo displayed in the **Photo 2** frame.

14. **Date** – shows the date at which the photo displayed in the **Photo 2** frame was captured.

15. **Clear All** – to clear both photos and reset the system.

16. **Library** – to open the **Library** window.

17. **Sensitivity slider** – to set the sensitivity of the cellulite threshold (default = 1).

18. **Sensitivity Edit** - to set the sensitivity of the cellulite threshold (default = 1).

19. **Improvement Index** – displays the improvement in cellulite appearance from photo1 to photo 2 (0 = no improvement, 1 = total improvement).

20. **Close** – to close the application.

21. **Surface Reflectivity** – to open the **TiVi95 Surface Reflectivity window**.

22. **Manual** – to display the on-line **TiTi95 Skin Surface Analyzer** manual.

23. **About TiVi95** – TiVi95 about window.

24. **Demo Assistant** – to open the Demo Assistant.
4.2 Surface Analyzer TiVi95 Library window

1. **Load Photos** – to upload new photos to the **Library** (only photos with the prefix “Cell” can be uploaded). Navigate to the folder that hosts the photos and select the files by first clicking on the first file, then pressing the **shift** button on the computer keyboard, while the last file is selected. Alternatively individual files can be selected while pressing the **Ct** button on the computer keyboard, while clicking on the actual file name.

2. **Sensitivity slider** – to set the sensitivity of the cellulite threshold (default = 1).

3. **Sensitivity Edit** - to set the sensitivity of the cellulite threshold (default = 1).

4. **Photo** – to display the photo only.

5. **Mixed** – to display the cellulite area superimposed on photos.

6. **Trend** – to display the trend diagram showing the successive changes in **Improvement Index**.
7. **Library** – to toggle back to the Library display.

8. **Export** – to export the **Improvement Index** data to an MS Excel ® spreadsheet.

9. **Close** – to close the Library window.

10. Below each photo the **Name, Date** and **Improvement Index** are displayed. The **Improvement Index** is displayed in red and refers to the cellulite improvement in relation to the first photo (also denoted Reference Photo).
4.3 Surface Reflectivity window

Using the *Surface Reflections* window the optical reflectance from a surface can be investigated by analyzing photos captured in cross- and co-polarization mode. The process starts with capturing two photos (one in cross- and one in co-polarization mode) of the same object.

1. Set the system to co-polarization mode by turning the Illuminator to a position where the back steering pint touches the magnet.

   CR-polarization mode: two white dots next to each other.

   CO-polarization mode: two white dots at 90 degrees apart.

2. Open the *TiVi701 Camera* window by selecting *Camera* in the *File* pull-down menu.

3. Click the *Save Photo* button and insert the name “skin_COCR2” to save the photos under the name with the prefix “skin_COCR2”.

4. Set *No of Photos* to 2.

5. Set *Delay* to 5.

6. Capture one co-polarized photo enhancing the surface reflections and then immediately click the *Pause* button to halt the photo capturing process.

7. Set the system to cross-polarization mode by turning the Illuminator to a position where the red steering pin touches the magnet.

8. Without changing the position of the object in relation to the camera capture the cross-polarized photo enhancing sub-surface structures by clicking the *Continue* button.
9. Two photos captured in the cross- and co-polarization mode respectively are now stored under the names *skin_COCR2-0001* and *skin_COCR2-0002* respectively.

10. In the following example these two files are pre-stored as examples in the folder *Skin_COCR* in the *TiVi95* demonstration folder. In these two photos a cream has been topically applied to the skin. The surface reflectivity of skin areas with and without cream is to be compared.

11. Open the *TiVi95 Skin Surface Analyzer* window.

![Image of TiVi95 Skin Surface Analyzer window]

12. Open the *Surface Reflections* window by clicking *Surface Reflectivity* in the pull-down menu.
13. Click the **Load CO Photo** button and navigate to the *Skin_COCR* folder located in the *TiVi95demostration* folder. Double click the *skin_COCR-0001.jpg* file to upload this photo.

14. Click the **Load CR Photo** button and navigate to the *Skin_COCR* folder located in the *TiVi95demostration* folder. Double click the *skin_COCR-0002.jpg* file to upload this photo.
15. In the Co-Polarized Photo frame, the *skin_COCR-0001* photo is displayed.

16. In the Cross-Polarized Photo frame, the *skin_COCR-0002* photo is displayed.

17. In the Difference Photo frame, the difference between the Co-polarized and the Cross-polarized photo is displayed. Negative values are displayed in black colour.

18. In the Total Int of diff photo the intensity of the difference photo over the total intensity region is initially displayed. Areas with high surface reflection are displayed in brighter colours.

19. Select Red Region in the popup menu. The lower right frame now displays differences in the Red Region for pixels with values above the Threshold (with *Threshold* initially set to zero. In this particular case the relative number of pixels is displayed as *Rel Surf Refl (%)*: 5.65 which is a measure of the reflectivity caused by the presence of the applied cream within the red colour region.
20. Move the Threshold % slider until the associated edit box displays 10%. The Rel Suraf Refl (%) is now reduced to 3.25 reflecting the relative number of pixels with a value above 10% of max value in the Red Region.

21. The popup alternatives are as follows:

*Total Region*: The Relative Reflectivity above set Threshold for the entire bandwidth.

*Red Region*: The Relative Reflectivity above set Threshold for the red bandwidth region.

*Green Region*: The Relative Reflectivity above set Threshold for the green bandwidth region.

*Blue Region*: The Relative Reflectivity above set Threshold for the blue bandwidth region.

22. Click the Curves button to open the Surface Reflections Diagram window. This diagram displays the Relative number of pixels above threshold (%) as a function of Threshold (% of max). The four curves represent the surface reflectivity distributions within the different wavelength regions.
23. Click **Export Data** to save the data of the diagram in an *Excel* spreadsheet.

24. Click the **Close** button to close the **Surface Reflections Diagram** window.

25. Click the **Close** button to close the **Surface Reflections** window.