The effects of moisture on fingertip skin deformation during loading and slipping

André T.¹,², Lévesque V.³, Hayward V.⁴, Lefèvre P.² and Thonnard J-L¹

¹ Rehabilitation and physical medicine unit, Université catholique de Louvain, Belgium; ² Center for Systems Engineering and Applied Mechanics, Université catholique de Louvain, Belgium; ³ Haptics Laboratory, McGill University, Montreal, Canada; ⁴ Institut des Systèmes Intelligents et de Robotique, Université Pierre et Marie Curie, Paris, France

INTRODUCTION

During tactile interaction, skin deformation stimulates the mechanoreceptors, enabling the nervous system to become aware of the properties of the touched surface. Even on perfectly smooth, glassy surfaces, the fingertip skin deforms in complicated ways when slip occurs. The aim of the present study is to assess the effects of moisture content and interaction forces on the fingertip skin deformation occurring in this condition.

METHODS

A: Optical system used "frustrated total internal reflection" to obtain high contrast fingerprint images.

B: Components
- Infra-red light source
- Polarizers
- CCD camera (Sony ICX449 at 60 Hz) + camera

C: Interaction force and moments measured with a C101ыва (ATI Wallace).

D: The complete system

Experiments
- 10 subjects
- Focus on the period when the finger is between the stick state and the sliding state
- 5 slipages for 5 given Normal Forces (0.2, 0.5, 1.5, 3, 5 N)
- Skin hydration measurements before and after slipages (Corneometer)

Image processing

Original Images

Optical Flow

Elliptical Fitting

Parameters Definition

The image registration was done using the optical flow technique. Recomposing two images, a gradient of displacement was obtained for each pixel. Black color corresponded to no displacement, gray level coded the level of displacement (the lighter, the greater).

INTRODUCTION

During tactile interaction, skin deformation stimulates the mechanoreceptors, enabling the nervous system to become aware of the properties of the touched surface. Even on perfectly smooth, glassy surfaces, the fingertip skin deforms in complicated ways when slip occurs. The aim of the present study is to assess the effects of moisture content and interaction forces on the fingertip skin deformation occurring in this condition.

METHODS

A: Optical system used “frustrated total internal reflection” to obtain high contrast fingerprint images.

B: Components
- Infra-red light source
- Polarizers
- CCD camera (Sony ICX449 at 60 Hz) + camera

C: Interaction force and moments measured with a C101ыва (ATI Wallace).

D: The complete system

Experiments
- 10 subjects
- Focus on the period when the finger is between the stick state and the sliding state
- 5 slipages for 5 given Normal Forces (0.2, 0.5, 1.5, 3, 5 N)
- Skin hydration measurements before and after slipages (Corneometer)

Image processing

Original Images

Optical Flow

Elliptical Fitting

Parameters Definition

The image registration was done using the optical flow technique. Recomposing two images, a gradient of displacement was obtained for each pixel. Black color corresponded to no displacement, gray level coded the level of displacement (the lighter, the greater).

INTRODUCTION

During tactile interaction, skin deformation stimulates the mechanoreceptors, enabling the nervous system to become aware of the properties of the touched surface. Even on perfectly smooth, glassy surfaces, the fingertip skin deforms in complicated ways when slip occurs. The aim of the present study is to assess the effects of moisture content and interaction forces on the fingertip skin deformation occurring in this condition.

METHODS

A: Optical system used “frustrated total internal reflection” to obtain high contrast fingerprint images.

B: Components
- Infra-red light source
- Polarizers
- CCD camera (Sony ICX449 at 60 Hz) + camera

C: Interaction force and moments measured with a C101ыва (ATI Wallace).

D: The complete system

Experiments
- 10 subjects
- Focus on the period when the finger is between the stick state and the sliding state
- 5 slipages for 5 given Normal Forces (0.2, 0.5, 1.5, 3, 5 N)
- Skin hydration measurements before and after slipages (Corneometer)

Image processing

Original Images

Optical Flow

Elliptical Fitting

Parameters Definition

The image registration was done using the optical flow technique. Recomposing two images, a gradient of displacement was obtained for each pixel. Black color corresponded to no displacement, gray level coded the level of displacement (the lighter, the greater).

INTRODUCTION

During tactile interaction, skin deformation stimulates the mechanoreceptors, enabling the nervous system to become aware of the properties of the touched surface. Even on perfectly smooth, glassy surfaces, the fingertip skin deforms in complicated ways when slip occurs. The aim of the present study is to assess the effects of moisture content and interaction forces on the fingertip skin deformation occurring in this condition.

METHODS

A: Optical system used “frustrated total internal reflection” to obtain high contrast fingerprint images.

B: Components
- Infra-red light source
- Polarizers
- CCD camera (Sony ICX449 at 60 Hz) + camera

C: Interaction force and moments measured with a C101ыва (ATI Wallace).

D: The complete system

Experiments
- 10 subjects
- Focus on the period when the finger is between the stick state and the sliding state
- 5 slipages for 5 given Normal Forces (0.2, 0.5, 1.5, 3, 5 N)
- Skin hydration measurements before and after slipages (Corneometer)

Image processing

Original Images

Optical Flow

Elliptical Fitting

Parameters Definition

The image registration was done using the optical flow technique. Recomposing two images, a gradient of displacement was obtained for each pixel. Black color corresponded to no displacement, gray level coded the level of displacement (the lighter, the greater).

INTRODUCTION

During tactile interaction, skin deformation stimulates the mechanoreceptors, enabling the nervous system to become aware of the properties of the touched surface. Even on perfectly smooth, glassy surfaces, the fingertip skin deforms in complicated ways when slip occurs. The aim of the present study is to assess the effects of moisture content and interaction forces on the fingertip skin deformation occurring in this condition.

METHODS

A: Optical system used “frustrated total internal reflection” to obtain high contrast fingerprint images.

B: Components
- Infra-red light source
- Polarizers
- CCD camera (Sony ICX449 at 60 Hz) + camera

C: Interaction force and moments measured with a C101ыва (ATI Wallace).

D: The complete system

Experiments
- 10 subjects
- Focus on the period when the finger is between the stick state and the sliding state
- 5 slipages for 5 given Normal Forces (0.2, 0.5, 1.5, 3, 5 N)
- Skin hydration measurements before and after slipages (Corneometer)

Image processing

Original Images

Optical Flow

Elliptical Fitting

Parameters Definition

The image registration was done using the optical flow technique. Recomposing two images, a gradient of displacement was obtained for each pixel. Black color corresponded to no displacement, gray level coded the level of displacement (the lighter, the greater).