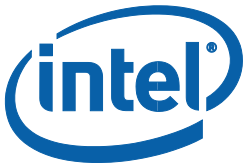

Localized Adaptive Contrast Enhancement (LACE)

Graphics Driver – Technical White Paper

September 2018

Revision 1.0

1 Purpose and Scope of this Document

This white paper provides an overview of LACE: Localized Adaptive Contrast Enhancement, Platform requirements, Software installation guide, i.e. setting Intel® Graphics Control Panel, etc., and FAQs.

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2 Overview of LACE

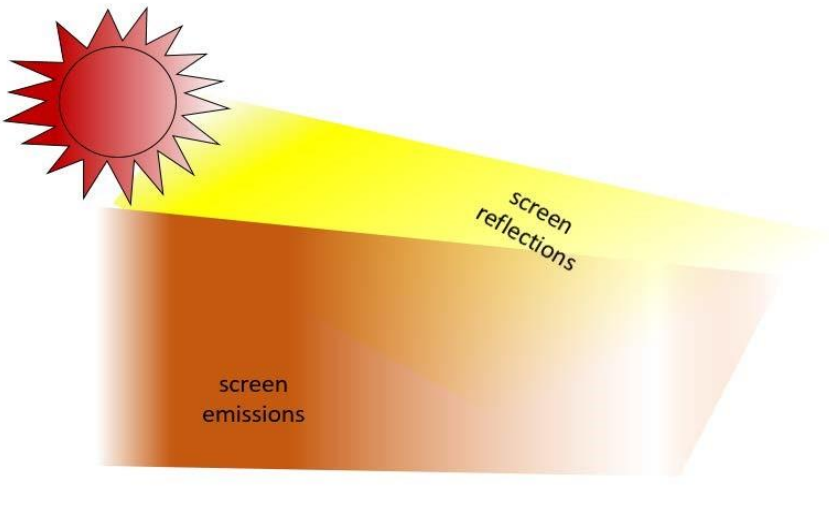
2.1 Introduction

LACE is a display post processing technique which is targeted to provide better user experience under high/bright light conditions such as reading/viewing display contents in sunlight.

LACE technology will work on internal displays and has support on eDP and MIPI. LACE can co-exist with current display technologies such as PSR1 (Panel Self Refresh), PSR2, VDSC, CoG/MSO, and Adaptive Sync. Co-existence with other display technology is covered later in this document.

2.2 Current Challenges and Why LACE is Very Effective

We face lots of challenges in the mobile viewing environment where it is difficult for emissive displays to compete with the sun's brightness.



Display contrast ratio is affected independently from the bright and dark ends of the range and therefore the contrast ratio must be adapted independently. LACE display Technology is very effective here because of the fact that it enables independent adjustment of bright and dark regions of each frame thereby having the brightness to be set according to preference and since it decouples brightness from contrast ratio the contrast ratio is always correct for optimal multimedia viewing.

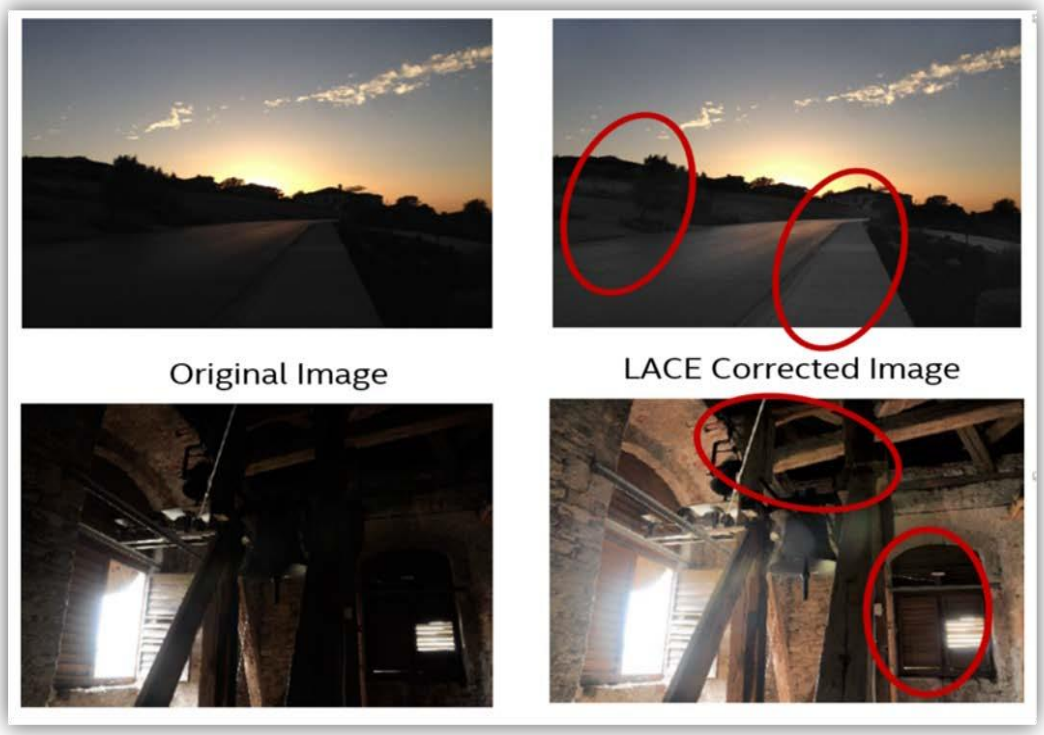
2.3 Benefits of LACE Display Technology

Better view ability of screen content (multimedia playback/browsing/doc reading/image viewing/etc) under bright light/sunlight environmental conditions.

2.3.1 View Photos/Movies in any Conditions

	LACE:
Display at max brightness: Contrast ratio is too low for multimedia	Content adapted to display contrast ratio at a High setting

Note: The above pictures are taken from external camera, the screen reflection, ambient conditions will affect the external camera quality.


Original Image
LACE Corrected Image

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3 Software Architecture

3.1 LACE Software Processing

1. Input: Histogram bins

Screen will be divided into tiles, each tile will have histogram data

2. LACE Processing:

    a. Read all histogram from each tile that cover the whole display

Execute the algorithm to calculate Image Enhancement for all tiles based on darker/brighter regions.

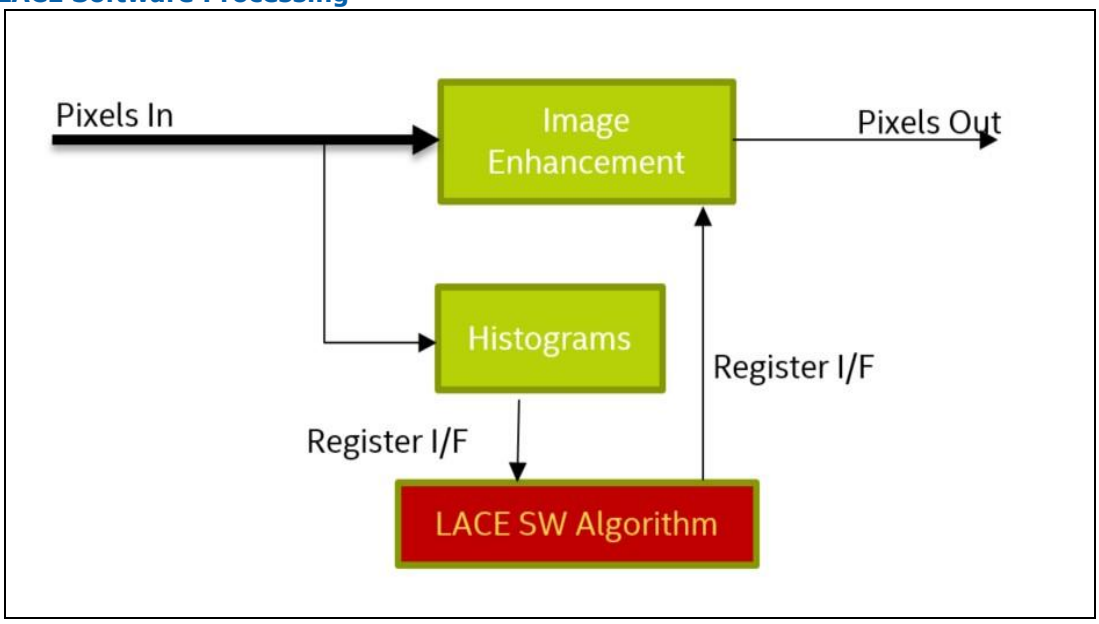
Program the results to all tiles

3. Output:

    a. Each tile will have enhanced Image constructing the whole image with contrast adjustments based on the darker/brighter part.

Below figure shows high level diagram of LACE Software processing.

Figure 1. LACE Software Processing



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4 Platform Requirements and Settings

4.1 Pre-requisites to Enable LACE Technology on Intel Platform

- Gemini Lake and later supported products combined with supported Graphics drivers.
- eDP Panel/MIPI Panel
- Ambient Light Sensor

4.2 Enabling LACE

LACE is a feature that is enabled by default within the Video BIOS though it can be controlled by the OEM to be disabled if unsupported.

Customization:

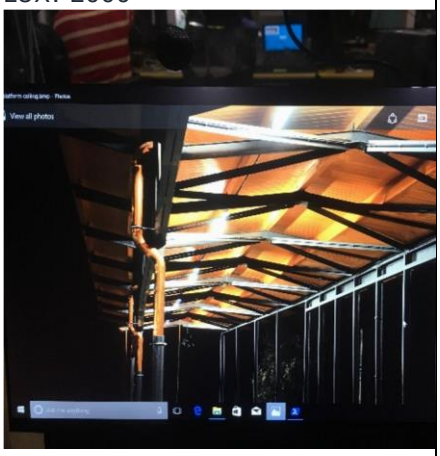
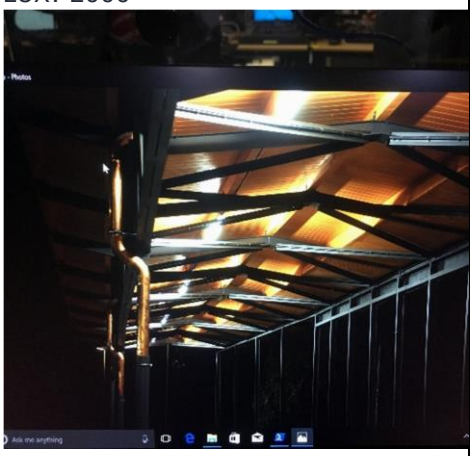
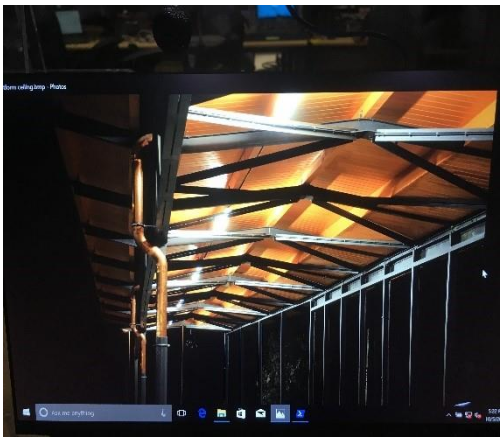
- LACE is enabled by default in Video BIOS
  - LACE option will be provided in the Intel® Graphics Control Panel as shown in the figure 2 below (if not disabled by OEM).
  - **Display LACE support**: This option to be used to enable/Disable LACE from platform.
  - **Display LACE enabled Status**: This option to set default state of LACE on Intel® Graphics Control Panel.
- If there is no ALS (Automatic Light Sensor) on board, OEMs are expected to Disable LACE in the Video BIOS.
- Intel® Graphics Control Panel will hide the LACE controls if there is no ALS present on system.

Figure 2. Intel Graphics Control Panel Snapshot for LACE Enable/Disable for End User Control (if enabled)

4.3 LACE Aggressive Level Definition

- User is not be able to change these settings dynamically. The Intel® Graphics Control Panel will not show controls on UI.
- OEMs will need to set this based on the requirements before shipping their system to market.
- **Recommendation**: Moderate setting
- **Default value in Video BIOS**: Moderate Setting

4.3.1 Visual Impact of Different Settings:

High	Minimum	Moderate(Default)
LUX: 2000 	LUX: 2000 	LUX: 2000 

Note: These pictures are taken from external camera, changes can be clearly differentiated with bare eyes.

4.4 LACE External Feature/Component Dependencies

Display Features	Co-Exist
DPST	Yes
PSR1/PSR2	Yes
3D HW LUT/DPP	Yes
VESA Display Stream Compression	Yes

Display Features	Co-Exist
Apical Display Technology	No
CABC	No
HDR Playback	No
Media ACE	No

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5 Capabilities/Limitations

1. Max. Resolution capability: 4096 horizontally and 2304 vertically /2304 horizontally and 4096 vertically pixels.
2. There will be minor visual artifacts seen in certain scenarios, like random window dragging.
    a. Intel® Graphics Control Panel tool tip will have the limitation info called out.

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6 FAQ

1. Is ACE sync side specific or platform specific?

   Answer: LACE is platform specific, Gemini Lake and later platforms will have support for LACE.

2. Can a system without ambient light sensor have LACE technology in it?
   Answer: No, LACE is triggered by ALS values.

3. What is the LACE impact on power?
   Answer: Since the contrast will be boosted by calculating histograms to provide better user experience, there will be a very small amount of power impact with Higher LUX values.

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