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Deliverable D3.2.1 Specification of 3D camera HW module

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Authors and Contributors: Tamás Forgács, Attila Fekete, Zoltán Megyesi

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DELIVERABLE SUMMARY SHEET

Project Number: 213349

Project Acronym: 3DPHONE

Title: All 3D Imaging Phone

Deliverable N°: D3.2.1

Deliverable Title: Specification of 3D camera HW module

Delivery Date: 31 Augustus 2008

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Short Description:

Present document has been prepared in fulfillment of **Deliverable 3.2.1,** required as an intermediate result of Work Package 3 of the ***EU Seventh Framework Program*** **ALL 3D IMAGING PHONE Project**.

Specification of 3D camera HW module means the description of the 3D camera related hardware, low level software, mechanical and optical components which will be developed and integrated in the project.

Contents

Acronyms and Abbreviations

2D	Two dimensional
3D	Three dimensional
API	Application Programming Interface
BUS	It is a subsystem that transfers data between components inside a device
CCD	Charge-Coupled-Device
CMOS	Complementary Metal Oxide Semiconductor
CSI	Camera Serial Interface
FPS	Frame per Seconds
FSC	Field Sequential Control
HW	Hardware
I2C	Inter-Integrated Circuit
JPEG	Joint Photographic Experts Group image compression standard
MDK	Mobile Developer Kit
MEMS	Micro Electro Mechanical Systems
P2P	Point-to-point, a telecommunications term connecting two items
PCB	Printed Circuit Board
RGB	Red Green Blue color space
SOM	System On Module
SVGA	Super VGA (800*600)

SW	Software
SXGA	Super XGA (1280*1024)
VGA	Video Graphics Array
WVGA	Wide VGA (800*480)
XGA	Extended Graphics Array (1024*768)

The 3D camera HW module's overall architecture

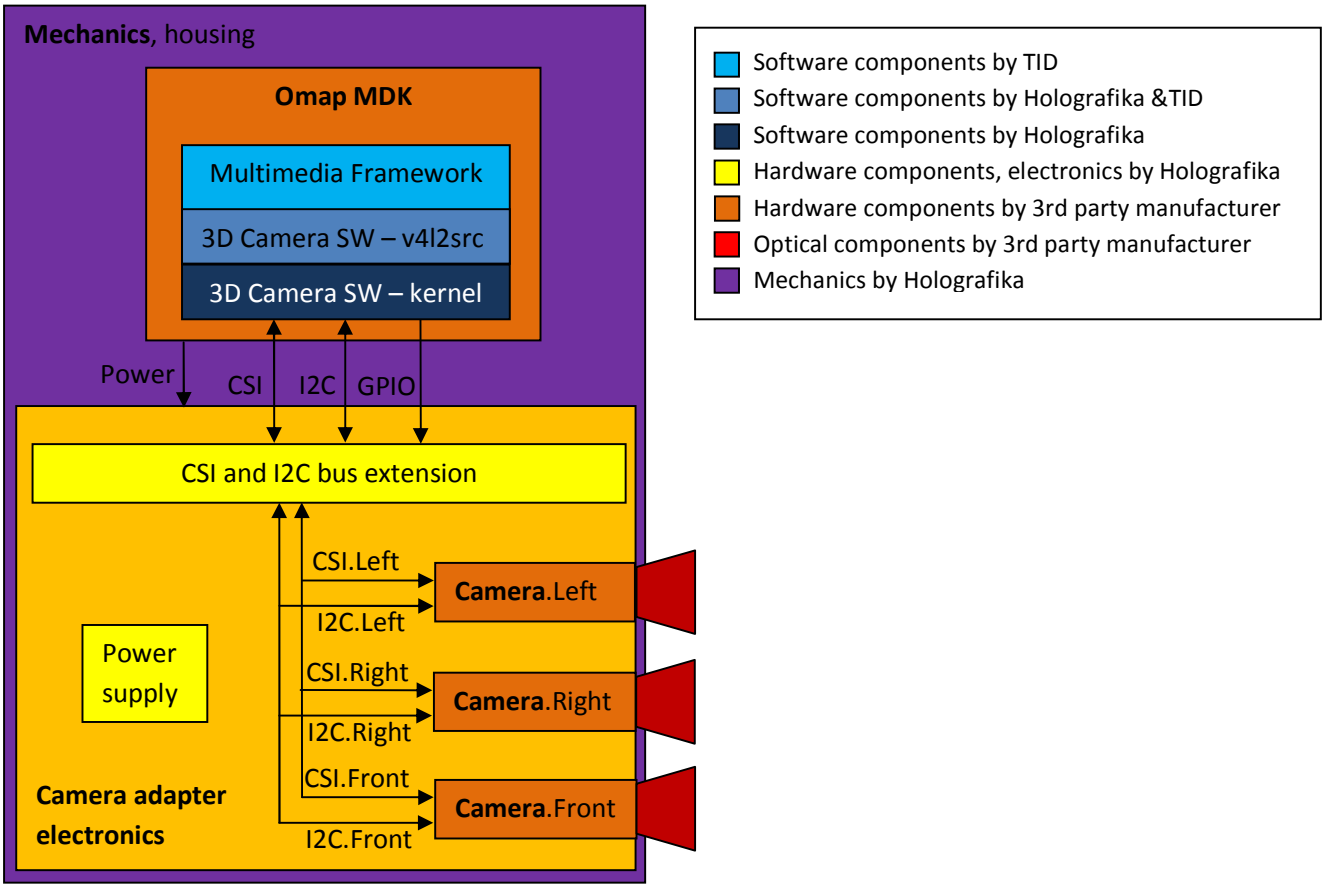
The purpose of the 3D camera HW module is to provide live 3D photos and videos for the 3DPhone device. The 3D camera HW module will be built in to the 3DPhone base device. The 3D camera HW module as a component includes the necessary SW components.

System Hierarchy

The main parts of the 3D camera HW module are the following:

- Camera adapter electronics
- 3D Camera Software
- Mechanics and housing

The block scheme of the entire system is illustrated on 1. Figure System Block Scheme, which also highlights the assignment of the participants of the 3DPhone project.



1. Figure System Block Scheme

Global 3D Camera Parameters

The following table represents the global parameters of the proposed 3D camera HW module. These are the approximate parameters of the addressed device, during project evolution some parameters might be changed.

Parameter name	***Specification***
Single camera resolution	2M Pixel (up to 1600x1200) or higher
Camera optics	fixed focus, F# 3.2, 52°horizontal f ield of view

Frame rate	up to 30Fps
Image output formats	ITU-R BT.656-4 YUV (YCbCr) 4:2:2 with embedded syncs, YUV (YCbCr) 4:0:0, RGB 565, RGB 444, JPEG, Bayer 10-bit or Bayer 8-bit
Operational power consumption	approx. 1W
Camera (eye) distance	6,5mm
3D camera mechanics	turnable or relocatable

Table 1 Global 3D Camera Parameters

Camera adapter electronics

The architecture of the camera adapter electronics can be followed on 1. Figure System Block Scheme.

There are three cameras supported by the Camera adapter electronics:

- two of them will form the 3D stereo camera (Camera.Left and Camera.Right)
- the third one (Camera.Front) is planned to be used for the followings:
    - gesture capture (optional)
    - 2D video conference (optional)

CSI and I2C bus extension

The Omap application processor (as well as the Omap Zoom MDK) has two interface related to camera devices, namely the followings:

- CSI (Camera Serial Interface): camera image data transfer channel
- I2C (Inter-Integrated Circuit): camera control channel

However multiple devices could be connected to the same I2C bus, each camera will be connected to the I2C bus via a multiplexer. In addition each camera will be configured to the same I2C device address. This way it is possible to realize both P2P and “broadcast” communication as follows:

- P2P: the Omap communicates with a single camera
- Broadcast: the Omap communicates with both left and right cameras in the same time

The CSI interface is implemented to connect a single camera image source device to the Host device (Omap). Low level signal buffering and multiplexing is needed to achieve proper connection between the Omap MDK and two or three cameras. This functionality is carried out by the CSI and I2C bus extension component, see 1. Figure System Block Scheme.

Stereo camera synchronization

Synchronization of the left and right cameras is needed to achieve proper 3D stereo image capture. It requires precise timing in case of 3D video capture and also in case of still image capture. The way of synchronization in the 3D camera HW module is as follows:

1., both the left and right camera is programmed to be prepared for "'FLASHGUN mode". In flashgun mode, the image sensor array of each camera is configured for use with an external flashgun. When a flash signal is triggered a single frame of image data is buffered in the left and right camera devices. The cameras will automatically switch to „Pause Mode" after the flash trigger.

2., The flash trigger signal is delivered (broadcasted) to both camera precisely in the same time via the I2C bus.

3., The stored image of the left and the right camera is transferred from the camera to the Omap after each other: first the left, than the right image.

4., The whole sequence will be repeated in case of 3D video recording.

3D Stereo Image transfer

As it was already mentioned in the previous section, the stereo images are transferred from the left and the right cameras in a fixed time multiplexing order. It means that the left image is transferred first, then the right image. It is repeated in case of 3D stereo video. The achievable 3D video frame rate is approximately 15 fps beside SVGA resolution and JPEG image format.

Camera Control

There are two layers of the camera control in the 3D camera HW module:

- the first is the control of the CSI and the I2C extender electronics
- the second is the original camera control flow

Each control layer is implemented through the standard I2C bus of the Omap device.

Control of the CSI and the I2C extender electronics

A single I2C bus will be utilized on the Omap device. The CSI and the I2C extenders will be assigned to dedicated device addresses, out of the range of the address space of the camera devices.

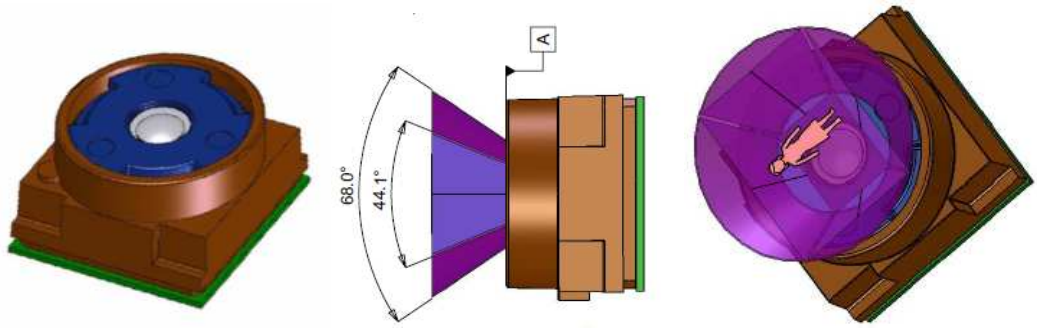
The CSI and the I2C extenders will use the same V2W protocol which is used by the cameras. The extender electronics will be able to process the following commands:

- select active camera, available values:
  - front camera (Default)
  - left camera
  - right camera
  - both left and right camera

Original camera control flow

The interface used on the VS6724 cameras is a subset of the I2C standard. Higher level protocol adaptations have been made to allow for greater addressing flexibility. This extended interface is known as the V2W interface.
This interface will be implemented on the Omap device. In the Technical Specification of the camera there are several messages specified to access the control registers of the camera. Through the manipulation of these registers, all the camera parameters can be controlled, such as the operation mode, image size, image format, etc. For details, please find ST's datasheet on the following URL: http://www.st.com/stonline/products/literature/ds/13399.pdf

Specification of SGS Thomson's VS6724 (summary)



2. Figure SGS Thomson's VS6724

SGS Thomson's VS6724 was selected as the most appropriate solution for the 3DPhone concept, because of the achievable highest frame rate. The characteristics of the preferred camera module are summarized in the table below.

Parameter	***Value***
Company	ST
Active pixels	1600H x 1200V
Size	8.0 x 8.0 x 5.55 mm ultra low profile
Image sensor	0.18 µm CMOS
Other features	Embedded hardware JPEG compression, Embedded camera controller, Integrated power management

3D Camera Software

The software components which will be used in the 3D camera HW module are the following:

- 3D Camera device driver modules
- GStreamer 3D camera source plugin (see D4.1.1 3DPhone Multimedia Framework)
- 3D Camera configuration and monitor tools

The goal with these software modules is to allow higher level applications to access and control the 3D Camera hardware through a convenient application interface. The highest level interface is the one defined by GStreamer framework for accessing stream sources. Therefore the highest level module will be a GStreamer 3D camera source plugin, which can be used in any standard GStreamer pipeline. The lower level modules will be put under the plugin by providing a standard API compliant to Video For Linux Two specifications. The configuration and monitor tools will be developed to provide the user better control over the devices. 3. Figure Components of the 3D Camera Software module shows the components of the 3D Camera software system, dashed objects mean optional or alternative components.

3D Camera device driver modules

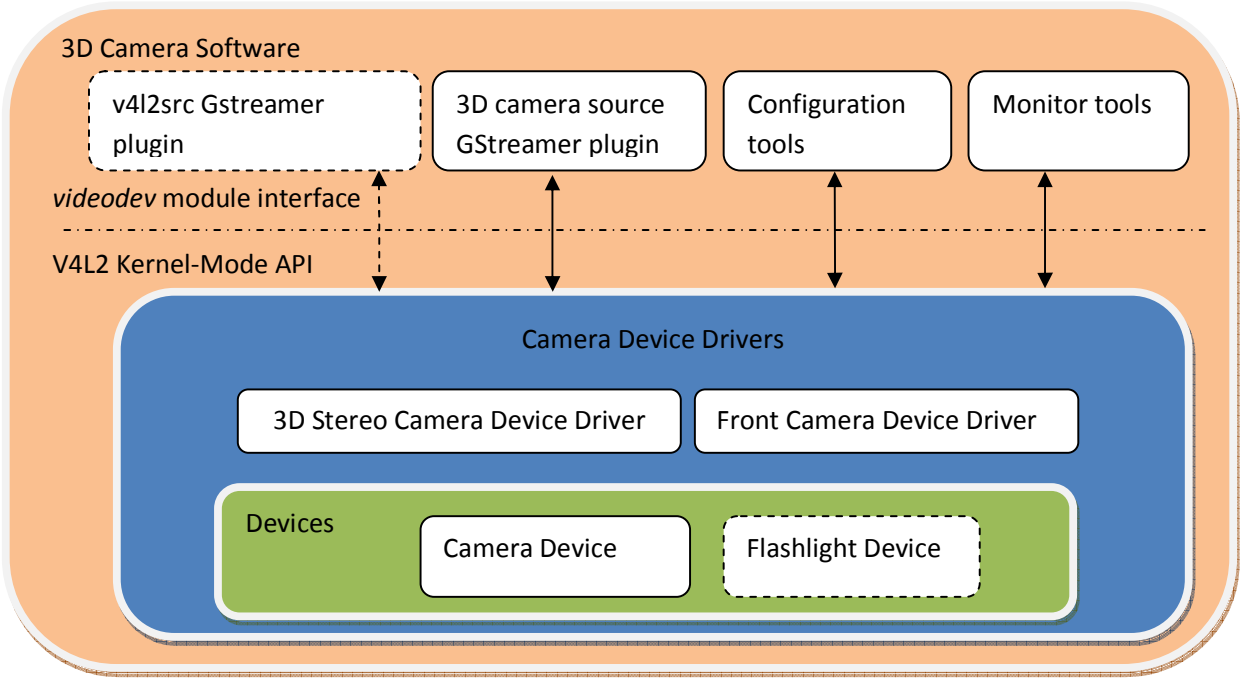
These modules are responsible for providing access to the camera hardware. For higher level of compatibility, the development aims to follow the Video For Linux Two driver mechanisms and development guidelines. Based on these guidelines, the goal is to develop *videodev* compatible *Omap Zoom* kernel modules that use the *V4L2 Kernel API*. An additional device layer might be necessary for low level control over the cameras and optionally over the flashlight (see 3. Figure Components of the 3D Camera Software module.).

GStreamer 3D camera source plugin

This software component will provide the link between the 3D Camera device drivers and the GStreamer media framework. The plugin will act as a standard GStreamer source plugin and will be usable in the GStreamer pipeline. The camera capabilities and operation modes will be controllable through control pads. Optionally the v4l2src GStreamer plugin might be used or extended with additional 3D camera related capabilities.

3D Camera configuration and monitor tools

These software components will be developed to provide the user better control over the 3D camera. The configuration tools will be used for adjusting capabilities and changing the operation modes of the 3D stereo and the front camera, while the monitor tools will be able to access status and information of the camera hardware. Both tools can be used during the development of the camera software to validate and fine-tune capability settings.



3. Figure Components of the 3D Camera Software module

Mechanics and housing

Mechanical Requirement

From the preliminary user requirement, it is clear the mechanics design must perform the smallest possible size. Another requirement is to make the 3D Camera HW module turnable or relocatable. This is necessary to enable both 3D photo shooting, 3D video recording and also for optional applications like 3D video conference.

The physical size constraints of the 3D camera HW module mechanics and the 3D phone base device housing are given by the mechanical dimensions of the following parts:

- Omap Zoom MDK baseboard, the Omap 3 SOM-LV module
- Omap Zoom MDK battery
- Omap Zoom MDK (3D) display and keyboard
- 2+1 pcs of VS6724 camera
- Camera adapter board

Therefore the minimum dimension of the 3D camera HW module is 80mm Width x 10mm Height x 10mm Depth.

The minimum dimension of the 3D phone base device housing is 95mm Width x 160mm Height x 25mm Depth.

To reach a good quality prototype the following manufacturing technologies are taken into account:

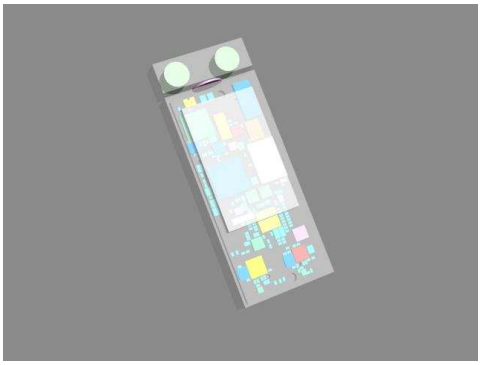
- plastic welding
- plastic milling
- rapid prototyping

The requirements for the mechanical design can be completed after having the requirements specified also for the 3D display HW module (deliverable D3.1.1).

Concept

There are two mechanical parts to specify for the 3D Camera HW module:

- 3D camera housing
- 3D phone base device housing



4. Figure Preliminary mechanical concept of 3D Camera HW module

3D camera housing

This piece of mechanics will contain the followings:

- 2 pcs of VS6724 camera (left and right camera)
- Camera board

The cameras together with the necessary DC coupling and cabling will be assembled to a small PCB. It is the Camera board, which is part of the Camera adapter electronics.

This mechanical part will able to be turned or relocated on the top of the 3D phone base device housing.

3D phone base device housing

This mechanical part can be either developed from the original housing of the Omap MDK or it can also be a new piece of mechanics. This will be decided after having the requirements also for the 3D display HW module (deliverable D3.1.1).

This part will contain the following components:

- Omap Zoom MDK baseboard, the Omap 3 SOM-LV module
- Omap Zoom MDK battery
- Omap Zoom MDK (3D) display and keyboard
- 1 pcs of VS6724 camera (front camera)
- Camera adapter board