

Conservatorio
di musica
Giuseppe
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IN PARTNERSHIP WITH  ximea

LoLa

Low Latency Audio Visual Streaming System

Installation & User's Manual

© 2005-2019 - Conservatorio di musica G. Tartini – Trieste, Italy
Version 2.0.0 (rev.001)

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1. Introduction

LoLa is an Audio Visual Streaming System developed by “Conservatorio di Musica G. Tartini”, Trieste, Italy, in collaboration with GARR, the Italian Academic and Research Network. LoLa goal is to provide a tool for real-time audio/video “natural” distance human interaction. It was originally conceived for distance music performances, education and production, but can be used for any other scenario where real-time interaction is required. A special attention has been paid to the optimization of the signal processing and transmission in order to keep the system latency as low as possible, below the human delay perception threshold. Both Standard Definition video (SD) and High Definition video (HD) modes are supported from version 1.4.x

The system is based on high performance and high quality audio/video acquisition hardware, and on the integration and optimization of audio/video stream acquisition, presentation and transmission. The LoLa system also requires very high performance Wide Area and Local Area Networks: 1 Gigabit per second end-to-end connection is the minimum suggested configuration when running the system with uncompressed video signals; lower bandwidth can be used when running LoLa with video compression on. A low latency in the network service is also needed.

Since November 2017, the LoLa development project also established a partnership with XIMEA (<https://www.ximea.com>). **XIMEA USB3 video cameras have proven on the field to be the technically best, cost effective and more reliable video hardware compatible with LoLa.** With this partnership we are able to better tailor both the technical camera features needed by LoLa, to provide better users' support and to provide custom interfaces and models: sharing common research also enables new vision features to further enhance the overall “LoLa users' experience”.

NOTE: LoLa depends on very specific hardware components and it works ONLY with some specific kind of cameras and audio cards; please carefully read the following “Hardware and Operating System requirements” chapter. LoLa DOES NOT work with webcams and embedded audio cards.

1.1. What's new

- LoLa version 2.0.0 supports multiple connections: currently 3 sites can be connected at the same time. See Chapter 4.
- LoLa now supports up to 4 cameras per site and you can switch between each one in real time. At the moment the camera selection is done by the local node only.
Note: In this version the cameras must be of the same type and model, or at least of the same Bayer pattern, max resolution and fps (i.e. don't use Ximea XiQ with XiC series because they differ in the bayer pattern).
- LoLa now supports also 2 network interfaces (NIC) at the same time, so you can in case have a separate NIC per each connection and share the network load.
- When scaling video resolution, now the image from the camera remains “centered”.

2. Hardware and OS requirements

In order to achieve a low transmission and presentation latency, LoLa relies on software optimization and on high performance audio and video devices. Low latency video in particular has been achieved by adopting a family of industrial specific cameras, which at the moment are only supported under the Microsoft Windows Operating System.

Historically LoLa has been successfully tested on Windows XP, Windows 7, Windows 8.1 and Windows 10 (both 32-bit and 64-bit versions).

*From ver. 1.4.0, support for Windows XP is discontinued; from ver. 1.5.0, support for 32-bit OS is discontinued. **LoLa v2.0.0 suggested OS is Windows 10, 64-bit version.***

2.1. Audio input/output hardware requirements

Low latency audio performance requires that small in/out audio buffers can be used, that no bottlenecks are present in the data transfer between the converters and the system, and that robust and efficient software drivers are available for the OS in use. Most USB and Firewire (IEEE 1394) external devices do not offer such a fast data acquisition processing, thus LoLa normally uses a PCIe internal device and a reliable ASIO driver. To date, the following Audio boards have been successfully tested and have shown very good performances with a buffer size of 32 samples (0.7 ms @ 44,1KHz):

- **RME HDSPe-AIO (PCI-Express internal card)**
- **RME MADIFX (PCI-Express internal card)**

We tested also the following external USB/Firewire cards/interfaces:

- RME Fireface 400 and 800 (Firewire)
- **Madiface and MADIFace Pro (Usb)**

with very good results using an audio buffer size of 64 samples and when supported by hardware device also with just 32 samples. *PCIe internal cards (at 32 samples) still perform better than external devices*, though, but also the above external ones provide acceptable results.

2.2. Video input hardware requirements

At the moment LoLa v.2.0.0 only supports the **USB3-Vision compliant cameras by Ximea**; these cameras provide high hardware performance and a versatile API for low-level video processing control. In future releases we will restart support Point Grey (now known also as FLIR) USB3-Vision cameras, too.

Please note that USB3 vision cameras do not require a frame grabber as they connect directly to appropriate USB3 ports.

2.2.1. XIMEA USB3-VISION XIQ AND XIC CAMERAS

In order to achieve the best performance for LoLa we currently use the xiQ and xiC camera series by XIMEA which provide low latency acquisition and reliable API/SDK for low-level programming.

All xiQ and xiC models by Ximea are compatible with LoLa. Currently extensively tested cameras are:

- XIMEA xiQ line: MQ013CG-E2
- XIMEA xiC line: MC023CG-SY

The recommended setup for Ximea cameras is 1280x720-Mono8, where Mono8 means that images are Bayer encoded. This mode reduce the required network bandwidth by 2/3 without losing quality.

2.2.2. Point Grey (now known also as FLIR) USB3-Vision cameras

Note: Point Grey USB3-Vision cameras are supported until version 1.5.0, but starting from version 2.0.0 they are temporarily not supported. In future releases we will still support them.

2.2.3. BitFlow dedicated video grabbers

Note: dedicated BitFlow video grabbers are supported for backward compatibility until version 1.5.0, but starting from version 2.0.0 they are no longer supported.

2.3. Video output hardware requirements

LCD monitors and projectors introduce additional latency w.r.t. CRT monitors. In order to achieve better video performance, use a fast LCD monitor with real low latency/response time (equal to or less than 1 millisecond). Monitors specifically designed for “online gaming profiles” usually are faster than standard ones.

The way you connect the monitor to the PC may also cause additional latency (some LCD monitors have different latencies for DVI, VGA and HDMI). In case you use any additional device, like video splitters, cable extenders, etc., please ensure that they do not add significant further latency to the video output chain. If you need dual video output, try to use graphic cards in the PC which already have native dual output, instead of using external splitting devices. In general beware that many video devices (including video walls, etc) are intended for broadcasting or streaming use, where latency is not important; thus the devices perform very badly when used with LOLA and should not be used. Some video projector have an acceptable low latency, but others perform very badly: check specifications before using them.

2.4. PC hardware requirements

LoLa software runs on a typical high-end gaming PC. A minimal suggested configuration consists in an Intel 6-core based system; for HD support we recommend a minimal i7 or i9 8-core processor with Hyperthread support, with at least 8 GB RAM; ***please note that Intel XEON and AMD processors are not recommended.*** Furthermore we suggest the following specifications:

- High performance motherboard providing PCI Express bus and supporting DDR4 ram technology. ***AsRock or Asus motherboards with Intel chipsets are highly recommended.***
- At least a 1Gigabit Network Interface port. LoLa v2.0.0 can also use 2 separate 1Gigabit Network Interface ports simultaneously, one per each connection. We strongly suggest to use Intel chipsets based Network Interfaces, and particularly the **Intel Gigabit CT desktop adapter** (EXPI9301CTBLK). ***See section 2.7 for important information regarding NIC performances.***
- Integrated graphic adapter should be enough for mid-range pc; however a PCI-Express Video Adapter by Nvidia (GeForce GTX series cards or better) is strongly recommended, specially for HD video processing and for the M-Jpeg GPU compression features.
- Enough PCI-express free slots to host Audio card, Graphic adapter, recommended USB3 adapters and additionally a compatible Intel NIC adapter.
- Mid/Full tower case with quiet design, a good air flow circulation and fans.
- A really good and stable PSU (Corsair AX series, Antec or Seasonic).
- ***A compatible USB3-VISION host adapter chipset. Tested and recommended USB3 adapters are:***
 - Fresco Logic FL1009 (395MB/s) and Fresco Logic FL1100 (395MB/s)
 - Renesas D720200AF1 (386MB/s), Renesas D720202 (365MB/s), Renesas D20200F1 (327MB/s)
 - Intel Z77 (450MB/s), Intel QM77 (450MB/s)
 - Asmedia ASM1142 (USB3.1)

Known incompatible USB 3.0 chipsets are: ASMedia AS1042, Etron EJ168A, Via Labs VL800-Q8, ASMedia xHCI. Texas Instruments chipsets do not work with Point Grey but they generally work with the Ximea cameras.

For a more comprehensive USB3 adapters list look at

- https://www.ximea.com/support/wiki/usb3/Compatible_hardware
- https://www.ximea.com/support/wiki/usb3/High_Performance_Hardware
- <https://www.ximea.com/en/products/usb3-vision-standard-designed-cameras-xiq/xiq-usb-30-accessories/4x-pci-express-adapter>

and for a more detailed hardware configuration list see Appendix C.

2.5. Network requirements

LoLa requires **per each remote connection** from at least 100Mbps in minimal uncompressed configuration up to 500Mbps and more in HD video uncompressed configurations (see the tables below) and generates a very high Packet Per Second (PPS) rate, e.g. from 100 up to 250 KPPS for HD uncompressed/unencoded video. Thus the minimal end-to-end connectivity for uncompressed mode (excluding uncompressed/unencoded HD where it goes beyond 1Gbps) **must be at least 1Gbps**. In general **please pay attention to the total traffic you are going to generate, accounting also the number of connections you are going to use per single Network Interface on your PC**. 1Gbps compliant cabling (Cat6 or optical), and adequate networking hardware is required: you should pay special attention to LAN switches performances when using LoLa, because of the high PPS rate, in particular when other data flow compete on the same switch (a typical **case which can create problems is a concurrent VoIP service**). In general the ideal situation is when the LoLa workstation is directly connected to the Wide Area Network device (router or switch) at 1Gbps with no other network devices in between, or at least there is no competing network traffic on the LAN devices being used by LoLa data traffic. Furthermore many older routers (like for example Cisco 3000, 7200 and 7300 series with NSE 100 or NSE 300 routing engines and equivalent ones) are also known to be unable to perform correctly with LoLa.

Lola also supports m-jpeg video compression; using compressed video the minimum required bandwidth is reduced to about 20Mbps (640x480, color, 30 fps) and allows you to control network bandwidth use in situations where you may hit the critical limits in uncompressed video mode. Video compression consumes hardware resources: without the use of a CUDA compliant graphic card, the PC CPU will be used and the overall video latency will increase from 1.5 (on hi-end 8-core and more CPUs) up to 5 milliseconds (on lower class CPUs), depending on video resolution. ***NOTE: on LoLa v2.0.0 CUDA compression is temporarily not available.***

The following tables give an approximate estimate of LoLa bandwidth traffic (***values in red indicate settings which may hit critical conditions when used with 1 Gigabit network connection***):

Uncompressed 8 bit (Bayer encoded – suggested configuration)

- 640x480 - 30 fps: ~ 85 Mbps
- 640x480 - 60 fps: ~ 170 Mbps
- 1024x768 - 30 fps: ~ 210 Mbps
- 1024x768 - 60 fps: ~ 420 Mbps
- **1280x720 - 30 fps: ~ 245 Mbps**
- **1280x720 - 60 fps: ~ 490 Mbps**
- 1280x960 - 30 fps: ~ 325 Mbps
- **1280x960 - 60 fps: ~ 650 Mbps**
- 1280x1024 - 30 fps: ~ 350 Mbps

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- 1280x1024 - 60 fps: ~ 700 Mbps
- 1392x1040 - 30 fps: ~ 385 Mbps
- 1920x1080 - 25 fps: ~ 495 Mbps

Uncompressed 24 bit (Color RGB)

- 640x480 - 30 fps: ~ 250 Mbps
- 640x480 - 60 fps: ~ 500 Mbps
- 1024x768 - 30 fps: ~ 620 Mbps
- 1024x768 - 60 fps: ~ 1240 Mbps
- 1280x720 - 30 fps: ~ 730 Mbps
- 1280x720 - 60 fps: ~ 1460 Mbps
- 1280x960 - 30 fps: ~ 965 Mbps
- 1280x960 - 60 fps: ~ 1930 Mbps
- 1280x1024 - 30 fps: ~ 1030 Mbps
- 1280x1024 - 60 fps: ~ 2060 Mbps
- 1392x1040 - 30 fps: ~ 1100 Mbps
- 1920x1080 - 30 fps: ~ 1700 Mbps

Compressed 24 bit (Jpeg comp. quality = 60)

- 640x480 - 30 fps: ~ 15 Mbps
- 640x480 - 60 fps: ~ 30 Mbps
- 1024x768 - 30 fps: ~ 25 Mbps
- 1024x768 - 60 fps: ~ 50 Mbps
- 1280x720 - 30 fps: ~ 30 Mbps
- 1280x720 - 60 fps: ~ 60 Mbps
- 1280x960 - 30 fps: ~ 40 Mbps
- 1280x960 - 60 fps: ~ 80 Mbps
- 1280x1024 - 30 fps: ~ 45 Mbps
- 1280x1024 - 60 fps: ~ 90 Mbps
- 1392x1040 - 30 fps: ~ 50 Mbps
- 1920x1080 - 30 fps: ~ 60 Mbps

LoLa should not run behind a Firewall and MUST run with a public IPv4 address (no NAT). IPv6 addresses are currently not yet supported. Traffic Shapers and other devices which inspect/act deeply on network performances must also be avoided. There can be network issues if the LoLa generated traffic goes via a number of Local Area Network Switches which are shared with other IP traffic: indeed LoLa generates a high rate of packets (PPS rate) as it uses 1K packet size, and this can affect performance of a number of LAN switches, resulting in a poor LoLa

end-to-end connection. A workaround can be to connect LoLa PC directly (or as close a possible) to the LAN edge routers connecting to the network backbone, to avoid switches.

As LoLa provides no error recovery procedures and a very minimal data buffering, the whole end-to-end network connection must be with very high performance: low jitter, error free and the lowest possible network latency (packets Round Trip Time, RTT); network latency adds in fact to LoLa system latency, and the sum define the upper limit when real-time human interaction is still possible. LoLa has been developed to use the services provided by the Research and Education hi-end networking services (like GARR, GÉANT, Internet2) and can run both on shared IP network services (TCP and UDP) or on dedicated circuits, which provide better network performances and reliability, especially at high bandwidth configuration. It is recommended to perform end-to-end network tests also using additional tools; *iperf* or equivalent (<http://iperf.sourceforge.net/>) can be used, trying to simulate LoLa expected traffic before using LoLa itself, but the best possible tests you can perform are using the **LoLa-Tester application**, which is included into the distribution package itself: in fact it generates a traffic which is very very similar to a real LoLa session (see section 5.3 for more details). These tools are also useful as a powerful network debugging aid, in case of problems using LoLa.

2.6. LoLa v2.x.x backward compatibility

Due to some newly introduced initial negotiation features, **LoLa v2.x.x is NOT backward compatible with older versions. Any attempt to connect with old versions will cause the remote application to crash.**

2.7. Network Interface Cards (NICs) performances

A number of NICs who declare a full 1Gbps capability are indeed unable to deliver it in full duplex, or have problems in delivering correctly the number of Packets per Second (PPS) generated by LoLa (up to 250000 in some cases). We identified issues with all the Realtek and Broadcom chipset based NICs. Also some Marvell NICs seem to have the same issues. We thus strongly suggest to get NICs which are based on Intel chipsets, because all Intel based NICs we tested perform correctly also with LoLa at high frame rates. Also some ASIX based NICs (88179 chipset) have good features, although not as good as Intel ones. We are currently testing also Aquantia 10Gbps network cards, but they are not yet certified for now.

INTEL NICs NOTE: we strongly suggest to modify the “**Interrupt Moderation Rate**” value to “**Medium**” (on Windows 7) or “**Low**” (on Windows 8.1 and Windows 10).

Generally the default setting is “Adaptive”, but during our tests we discovered that it's not good for LoLa. The same problem occurs if you completely turn off the interrupt moderation rate. Other chipsets may have similar possible controls: in such a case try not to leave it to automatic adapting, and keep it either medium or low.

3. Lola installation and system setup

Simply unzip the provided .zip file in a directory of your choice and *where you have all read/write permissions. It is right to place the LoLa folder on the Desktop, and you can safely keep more than one LoLa version (in different folders) on your PC. Then install drivers and libraries as follows.*

3.1. Common libraries/drivers installation

These libraries are required by all LoLa versions (Ximea and Point Grey).

3.1.1 WinPcap (ver. 4.1.3)

LOLA relies on the WinPcap windows packet capture library, which has to be installed on your PC before running LoLa. *You will find the correct installer version within the LoLa package inside the “WinpcapSetup” folder.*

3.1.2 Visual C++ 2010 and 2019 Redistributable package (x64)

Starting from version 1.4.0, LoLa is distributed with all the required Microsoft libraries, so it is no longer needed to download and install the Visual Studio C++ 2010 and 2019 Redistributable package.

However, in case you encounter some issues with the included libraries, you can manually download and install the package from:

<http://www.microsoft.com/en-us/download/default.aspx>

Read Appendix H.10 for further details.

3.1.3 RME Audio Card drivers

Download and install the latest available firmware and drivers from the audio board producer site:

<https://www.rme-audio.com/downloads.html>

3.1.4 Nvidia Graphics Card updated drivers (required only by Lola “_Cuda” versions)

NOTE: LoLa v2.0.0 does not temporarily support CUDA.

When using LoLa compiled with the Nvidia-Cuda support (LolaGui _Cuda versions), please make sure your Nvidia graphics card drivers are up to date.

If not download an updated version from Nvidia site:

<http://www.nvidia.com/Download/index.aspx>

3.2. Drivers for BITFLOW grabbers

Starting from version 2.0.0 BITFLOW grabbers are not supported.

3.3. Drivers for Ximea USB3-Vision systems

3.3.1 XIMEA API Software Package

You will find the correct XIMEA API installer within the Lola package inside the “XimeaSetup” folder.

In case you have installed a previous API version, you must first remove it and then install the new one.

After installing Ximea drivers and rebooting your pc, you can safely connect your USB3-Vision camera to the computer.

3.4. Drivers for Point Grey USB3-Vision systems

Note: Point Grey USB3-Vision cameras are supported until version 1.5.0, but starting from version 2.0.0 they are temporarily not supported.

3.5. Audio hardware Setup

Update/install the drivers first! (see section 3.1). Before using the software, it is highly recommended to check if there is any board setup panel providing latency settings on which the software applications have no control. The RME driver usually provides a DSP Setting Panel as the one shown in Fig. 1 (a link to it is usually available in the Windows bottom-right toolbar).

Set the hardware latency (Buffer Size) to the smallest available (32 samples or 0.7 ms). DSP setting panel might have a different look (it depends on driver versions), but they all have the same equivalent functionality. If your audio card does not support 32 samples, set the value to 64 samples: this often happens with external audio cards via USB or Firewire (see section 2.1).

Since version 1.4.0, when LoLa is launched, it will check your current buffer setting and, in case it doesn't correspond to the correct value, it will alert you with a warning message. LoLa will also check for all available audio ASIO devices and if none is available, the program will provide a warning message and run without audio support.

It will be possible to select the desired ASIO audio device from the *Audio Video Setup* dialog window, available in the *Tools* menu (Fig. 2). If you are unfamiliar with the audio card internal mixer settings, see *Appendix B*.

Starting from version 1.5.0, LoLa also supports a sample rate of 48KHz.

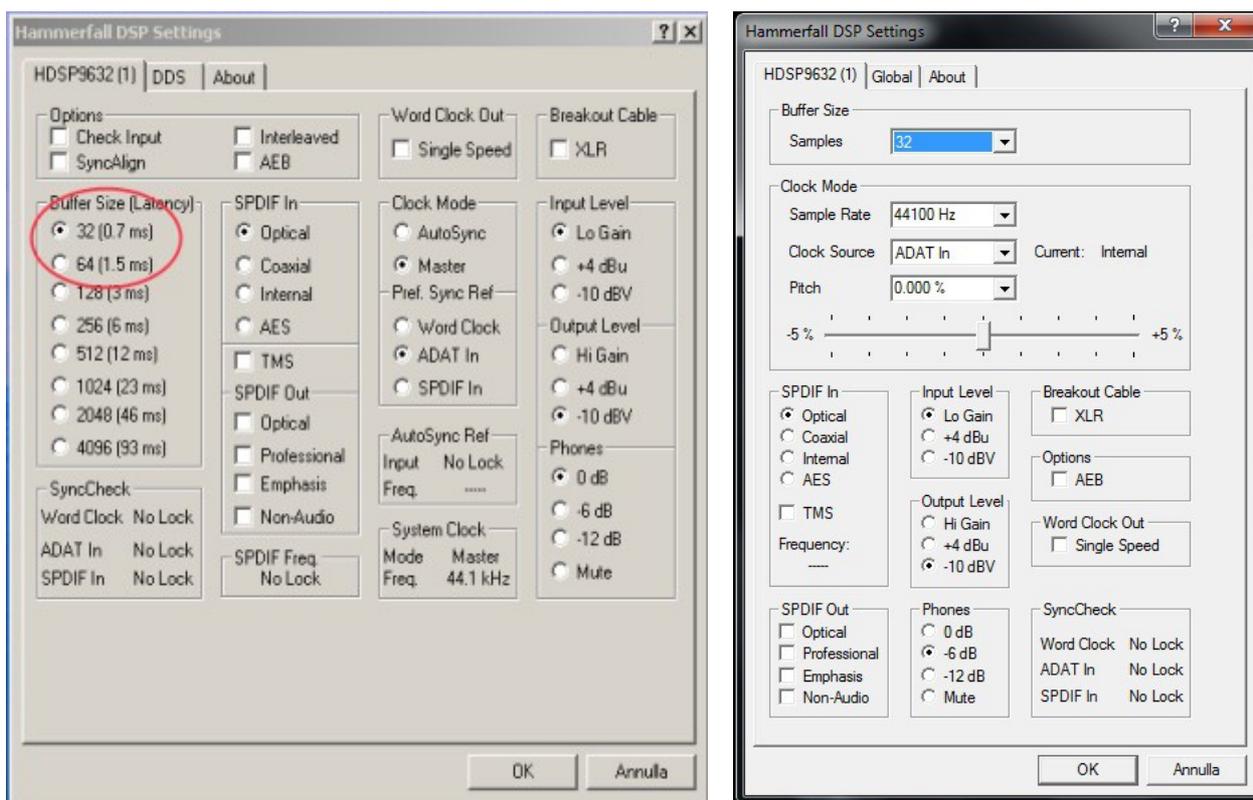


Figure 1: audio device control panel (2 different driver versions)

NOTE: do not use ASIO4ALL emulation drivers to use the internal PC audio system: performances are very poor and make LoLa audio totally unstable.

3.6. BitFlow Video hardware Setup

Note: BitFlow video grabbers and CXP cameras are supported for backward compatibility until version 1.5.0, but starting from version 2.0.0 they are no longer supported.

3.7. Running LoLa application

LoLa application itself does not need installation. To run LoLa just launch the *LolaGui_x.x.x_YYY.exe* application (x.x.x = version number, YYY = build info).

3.6.1 Activation code and first time run

The first time the software is launched, LoLa will ask you for a user identification and activation code. Just insert the ones you received with your license.

Then the Audio/Video setup dialog window will pop up (Fig. 2) asking for first-time device selection. The setup will then be stored in a *LolaGui.ini* configuration file in the Lola current directory and will be used in future sessions. You can always modify the Audio/Video setup starting

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from the *Options* menu, but only when LoLa is not connected to a remote node.

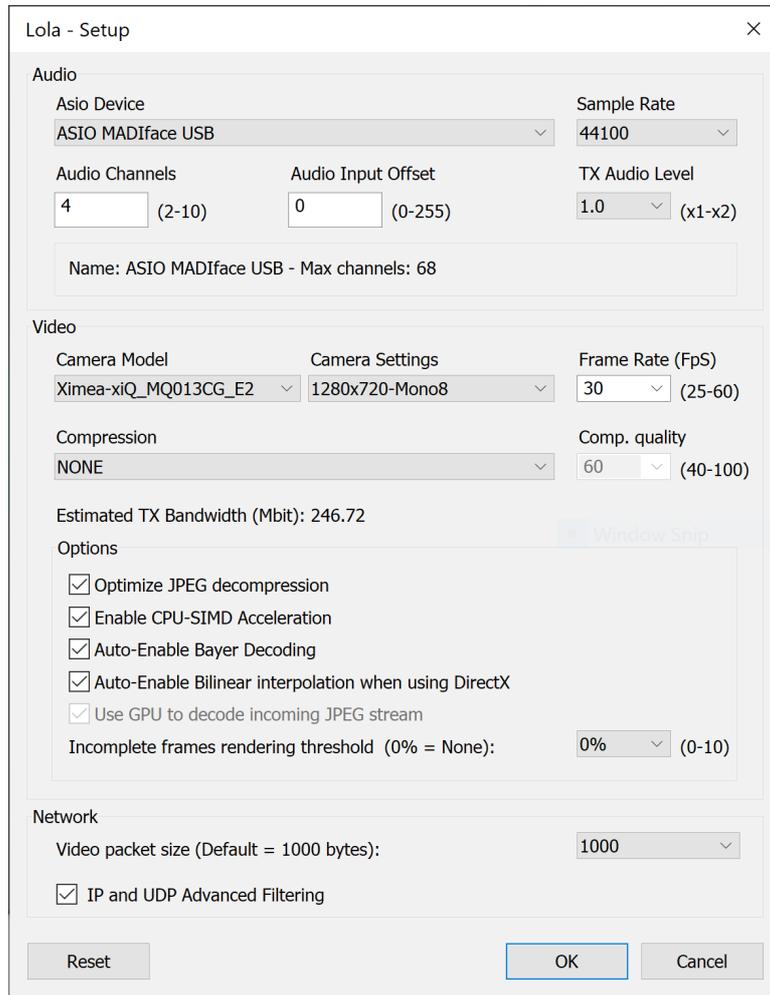


Figure 2: Lola Setup Dialog

LoLa 2.0.0 default audio setup is for 4 channels, collecting audio input from the first channels of the RME audio card, e.g. setting the “Audio Input Offset” to 0. LoLa will also remember these settings until you change them again.

You will also have the possibility to select the “N. of Audio Channels” from this menu; if you want to use more than 4 channels or you want to collect audio not from the first two channels of the RME audio card, see section 4.1 for further setup details.

TX Audio Level let you choose between “1” (no audio pre-amplification) or “2” (6dB audio pre-amplification). The default value “1” should be OK with most devices and setup, but in case you need to boost the level, you can use “2” instead. This affect only the audio you transmit to remote nodes.

In the “Video” section, select the camera file appropriate for your device. You can also configure your camera by selecting the appropriate “Mono8” or “RGB” files. Since version 1.2.1 LoLa supports all Frame Rates between 25fps up to 60fps. Of course the more fps the more bandwidth you will use. Standard values of 30fps or 60fps are commonly used.

In versions older than v2.0.0, the “Network” section also included the selection of the

Network Interface card to use for the connection. This selection is now done under each “connection tab”, as LoLa can use more than 1 Network Interface, and dedicate 1 interface to a remote host connection. See section 4.

Starting from version 1.3.0, LoLa can also compress video data. **By default compression is disabled** (“NONE” selected from the “compression” menu) since it introduces further latency and requires more processing power. It should be used only when there is not enough bandwidth available to run LoLa with uncompressed video data (see section 2.5 and section 4.1 for further details).

3.6.2 Changing the user identification and activation codes

If you need to change your user identification/activation code, just select the LoLa “Help” menu, and then “Update Serial”; upon confirmation your current codes will be removed. Quit the LoLa application and restart it in order to enter the new codes.

3.8. Tuning the LoLa Workstation

It is recommended to switch off other applications that might interfere with the audio/video streaming process when the application is used in production sessions: anti-virus scanning software or similar should be carefully disabled.

In case you notice some PC performance problems, it is suggested to disable the various “energy saving” options. The fine tuning of the Operating System for audio video streaming applications might also be advisable and please note that Windows firewall disables by default ICMP and thus LoLa capability to perform its initial “check” function with the remote partner; you can fix this by enabling ICMP responses in the Windows firewall configuration. *Also remember to turn off the screen saver.*

When using LoLa it's also suggested to:

- disable or uninstall any app that automatically connects to the internet or that takes internal resources (weather, skype, finance, games, mail, et.)
- put the desktop background on black color (so it's ready for the concerts)
- disable "Show taskbar" on all displays (so that the secondary monitor does not display the taskbar)
- **set your Windows "Power plan" to "High performance" (Control Panel → Power options);** depending on CPU we have seen some great performance improvements.
- disable screen shutdown (set it to nether) and disable any screensaver
- disable automatic updates (as long as Windows 10 will reactivate them); repeat this any time before using LoLa for a session so at least it does not makes updates in the next day.
- disable the firewall (firewall can cause 100% disk utilization on SSD devices)
- in "Security and Maintenance" choose Change settings Security and maintenance and disable all messages
- set Interrupt Moderation Rate of the Network Card to LOW or MEDIUM (see section 2.7)

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- **Disable 'Windows Background Apps'** (Windows 10, by default, runs a number of Apps in the background, regardless of whether you are using them):

Select 'Settings' from the Windows Start menu, select 'Privacy', then select 'Background Apps'. From here switch 'Off' all the apps that you do not believe you are using, or that you do not wish to run in the background when you are not using the program.

- **Disable Windows 10 quick start (Power options)**

Search for "Power Options". Click "Choose what the power buttons do". Click "Change settings that are currently unavailable". Click "Turn on fast startup (recommended)" so that the checkmark disappears. **Click Save changes.**

- Uninstall Microsoft One Note
- Disable or Uninstall Microsoft One Drive

3.9. UDP ports used by LoLa

LoLa will use by default ports UDP 7000, UDP 19788 and UDP 19798 for service communication and audio/video streaming. It is thus required that no restrictions apply for these ports (e.g. due to network or Windows firewall settings or local network administration policies). If you experience problems like “no connection”, or “video OK but no audio”, or “audio OK but no video” or “remote video window open but remains black screen” it is likely that some port filtering is affecting your connection. Please check your local network policies and also ask the remote site to do the same. You may also detect a filter is affecting LoLa if in “Network Monitor” panel (fig. 13, under “Tools” menu) you detect that no traffic is flowing while connected either in 1 direction or in both directions.

3.10. Local and Remote Audio/Video Quality

LoLa is just a tool which delivers to the remote site (in the best possible way) what it gets as input into the system locally; if you input good audio and good video, you will likely get good audio and good video delivered to the remote side. As such, remember to check locally your input before sending it to the remote system. Check your audio levels, check how microphones collect the sound, check the images the cameras are getting and the local lighting, etc.: remember the saying “garbage in → garbage out!”

3.11. Software you should not install or run on your LoLa PC

LoLa absolutely requires a perfectly “tuned” PC and so, in order to maintain your Windows installation as clean as possible, please don't install any Antivirus software, Skype or similar video conferencing applications, Apple software (iTunes or similar), VideoLan or other streaming systems, and in general all other tools or background services that could seriously affect the overall system and network performance. Also running a browser while LoLa runs is a very bad idea, especially if the web pages contain videos: YouTube playing can totally disrupt LoLa performances.

The ideal LoLa PC is based on a really clean Windows installation, with only the required drivers and tools for the audio and video cards and grabbers and no other software than LoLa itself.

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Please also check the correctness of your installed drivers, specially with regard to the RME card, BitFlow grabber and Network adapter.

If you wish to use the LoLa PC hardware also for other users, then the correect way to do this is to create different boot partitions on your PC, one dedicated to LoLa installation, accurately tuned for it, and others for other s/w and services.

4. Running LoLa

LoLa user interface (Fig. 3) is intended to be as simple as possible: a remote address to call (IPv4 address), a “Check” button to make a quick and simple pre-connection test, a “Connect/Disconnect” button. You can also “Save” your session configuration from the “File menu” and recall a previously saved setup configurations via the “File menu - Open” command; as the saved configuration file also includes the remote party IP address, you can use this feature to create your “LoLa address book”, where each entry also includes personalized setup parameters for the remote partner. Furthermore, LoLa also remembers the “last session” setup, thus it will always restart from the last session configuration. See also section 4.2 and Fig. 11.

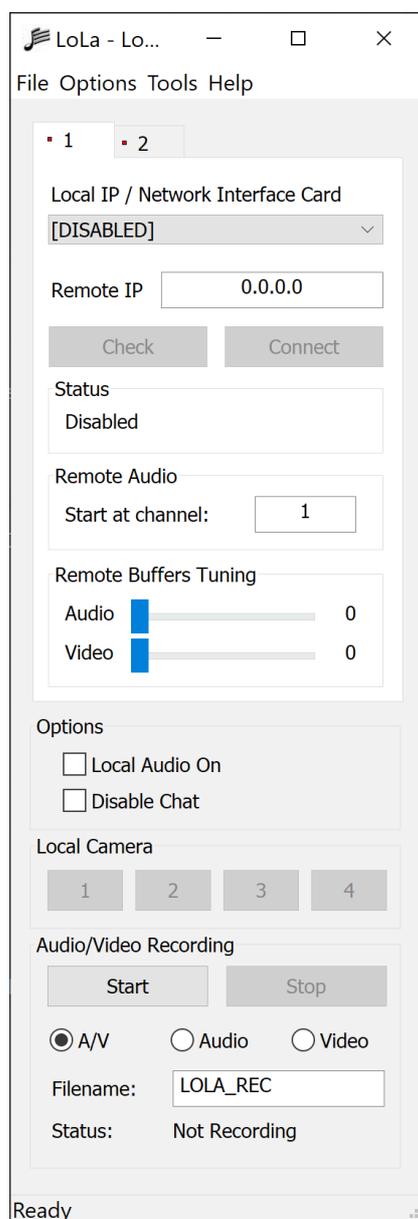


Figure 3: LoLa main window

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Starting from version 2.0.0, LoLa can also connect three hosts together, and each remote host is assigned to a “session” identified by one tab named “1” and “2”. For each session (tab) you can specify the network card to use for that connection, the remote IP address, on which channels to receive remote audio and also tune the remote A/V buffers. A little “led” in the tabs (near the session number) indicates the session state:

- **red** – Network Interface Card field is set to “(DISABLED)”; this session cannot accept or start a connection;
- **yellow** – this session is “enabled” and a NIC assigned to it, so you are ready to accept or start a new connection on it;
- **green** – on this session a connection with a remote host has been successfully established.

If your PC has more than one Network Interface Card, you can select which one LoLa will use to send and receive data for each session; in such a case, ***be sure to select the correct NIC for your session, otherwise LoLa cannot properly connect to the remote node.***

The “correct NIC” shall have correct hardware features (see section 2.7) and have a cable connected to the network. You can use the same NIC for both sessions, or use two separate NICs, one for each session, both connected to the network with different IP addresses assigned. As an example, if your PC has three NICs:

- NIC 3: Broadcom chipset, a “non correct NIC” for LoLa use,
- NIC 1 and NIC 2: Intel chipset, “correct NIC” for LoLa use,

you can assign NIC 1 both to session 1 and session 2, or assign NIC 1 to session 1, and NIC 2 to session 2, or NIC 2 both to session 1 and session 2, never using NIC 3 which does not perform ok. Using 2 NICs increases the total network bandwidth your PC can use for LoLa connections ONLY in case of 2 contemporary sessions, as each session can only reach the maximum bandwidth of its assigned NIC. Keep in mind, however, that using for example two NICs of 1Gbps each with two connections to your Local Area Network does not increase the total Wide Area Network (WAN) connection uplink bandwidth: if the WAN uplink is 1Gbps, you will still have 1Gbps only.

For use of the “Remote Buffers Tuning” see sections 4.5.

4.1. Local audio and video settings (LoLa Setup)

Before attempting to connect to a remote host, the user should correctly configure the local audio and video options. The *LoLa Setup* dialog (in the *Options* Menu, Fig. 2) allows to select the desired ASIO audio device, the video camera file, the desired video frame rate (25 up to 60 fps, but 30 or 60 are the standard suggested values) and the video compression (default is “NONE”). From v2.0.0 the network interface card is selected inside the “session” tab of the main window.

4.1.1 Audio setup

This section allows to set the number of used audio channels and to specify from which audio input channel from the RME audio card you shall collect the local audio input. You can control from which audio input channel LoLa shall receive input by using the “Audio Input Offset” setting. If set to 0 (default value), LoLa will receive audio starting from the first RME channel,

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which usually is an analog input one.

Starting from version 1.5.0, LoLa also supports a sample rate of 48KHz (menu Options → LoLa Setup → Sample Rate).

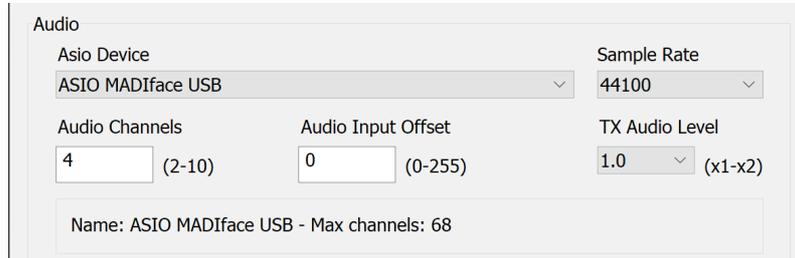


Figure 4: LoLa Setup, Audio section

As an example, imagine you have multichannel audio enabled and your audio card has the following list of input audio channels:

AN1 AN2 SP.L SP.R A1 A2 A3 A4 A5 A6 A7 A8

and you want LoLa to receive audio input from the 8 ADAT (A1-A8) channels. Then you need to set “Audio Input Offset” = 4, thus LoLa will skip the first 4 channels, and “N. Audio Channels” = 8 in the *LoLa Setup* dialog box. If you request more audio channels than available, LoLa will signal an error. An easy way to detect your RME audio card configuration is to see the HDSP Matrix from the card internal mixer (see appendix B). The “input channels” are listed as the top row in the matrix.

It is recommended to verify that audio input is working properly and the input latency is low as expected. A rough test can be done by switching on input-to-output redirection (using the “Local audio On/Off” flag available on the control panel in the main window, see Fig. 3) and using headphones connected to the LoLa audio card output to avoid an audio feedback effect. Further checks on the audio setup can be done using the appropriate audio card mixer/setup application (see for example Appendix B).

LoLa can also pre-amplify audio input by 6dB in case this is needed; just set “TX Audio level” to “2.0” if you want this pre-amplification to happen.

4.1.2 Video Setup

If the local video camera is connected and the correct camera file is selected, you should also see in the “Local Host” windows your local video. Also in this case you should check that the local video latency is low as expected. You should also check that the local audio and the local video are synchronized correctly. You should also watch your local video to correctly set the image framing, image focus, lens iris, camera sensor gain, color balance etc, in order to send the best possible image to the receiving hosts. If you use multiple cameras, do the check for each camera.

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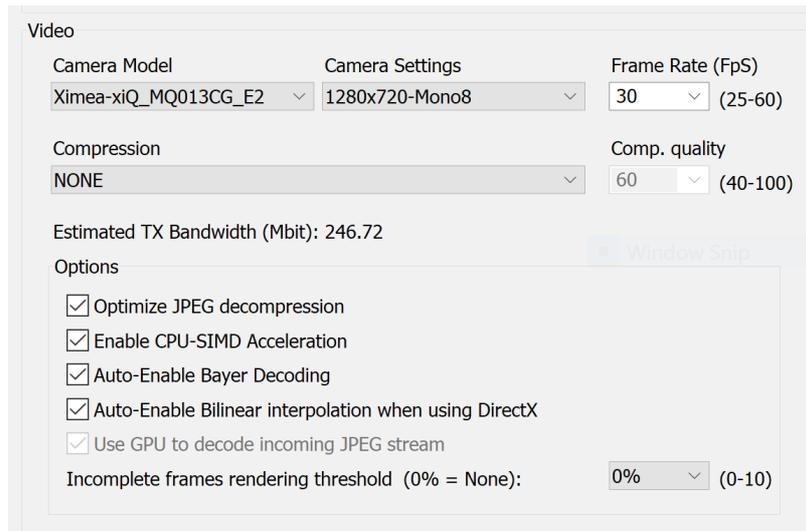


Figure 5: LoLa Setup, Video section

In this section you can control various video parameters:

- **"Camera Model" and "Camera Settings"** specify the camera model, its resolution and its pixel depth (8 bit for Mono8 or 24 bit for RGB).
- **"Frame Rate"**: here you can specify the frame per seconds of your camera. Inside the brackets on the right side of the "Fps" drop-down box, Lola indicates the minimum and maximum fps values reached by the camera at the chosen resolution.

To avoid video stuttering or tearing effects it's preferable to select a value which correspond to your monitor refresh rate or to the half; since generally the refresh monitor rate is 60Hz the suggested values are 30 or 60 fps.

- **"Compression"**: starting from version 1.3.0 it is possible to send and receive jpeg compressed video frames; this reduces the amount of transmitted/received data/packets so saving a lot of network bandwidth. In order to apply the compression, select from the drop-down menu the "M-JPEG" value; after selecting this option the *compression quality* drop-down menu will be available too (in brackets is indicated the compression algorithm: "CPU" indicates cpu-simd, "GPU" indicates gpu-cuda acceleration).

"Comp. Quality" indicates the overall video compression quality:

- 100% = high video quality but more cpu/gpu usage and compression time;
- 60% (default) = good balance between video quality and cpu/gpu performance;
- 40% = low video quality but low cpu/gpu usage and overall better performance.

Although it is also possible to compress Bayer encoded images, we recommend to use compression on 24-bit RGB images only, in order to avoid highly visible video artifacts.

- **"Estimated TX Bandwidth (Mbit)"** indicates the required network transmission bandwidth; for jpeg compressed streams it is an approximation. This value applies for each single session: if you run 2 sessions, you will send the double bandwidth.

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– Options:

- **"Optimize Jpeg Decompression"**: when activated LoLa uses a secondary thread to decompress the incoming jpeg stream in order to avoid issues with the audio buffers (LoLa Network Monitor → Realigned buffers). Generally the benefits depends on your cpu speed, number of cores and hyperthread support. If you see that your receiving video stream is stuttering (specially with frame rate higher than 50 fps) try to disable this option; when disable pay attention to the number of Realigned Buffers in the Network Monitor. The default is "enabled".

- **"Enable CPU-SIMD Acceleration"**: this option should be always enabled in order to achieve the better performance from your system. However, in the remote case you encounter some audio or video issues, you can try to disable it to resolve them. The default is "enabled".

- **"Auto-Enable Bayer Decoding"**: when activated LoLa tries to auto-detect Bayer encoded images and automatically debayering them. In case this doesn't work properly you can manually activate Bayer demosaicing by using the *Color Bayer Decoding* command available in the *Bayer Color* menu (Local/Remote windows). The default is "enabled".

- **"Auto-Enable Bilinear Interpolation"**: when using DirectX video acceleration LoLa automatically set image interpolation to "Bilinear" for a better image quality. Since this operation is directly done by your graphic card, it doesn't add any latency to the overall video rendering pipeline.

When you disable DirectX acceleration (by using *Disable DirectX Acceleration* command in the local/remote window *Options* menu) LoLa automatically set interpolation to "Nearest Neighbor". **In this case pay attention that using a zoom bigger than 100% may consume more CPU time and decrease the overall system performance**, specially if you reactivate bilinear interpolation; so if you hear clicks on audio or notice "stuttering" video effects set the window zoom to 100% and interpolation to "Nearest neighbor".

- **"Use GPU to decode incoming JPEG stream"**: here you can specify to use or not the GPU to decompress incoming stream; the overall decompression speed depends on your GPU card model. You can monitor the decompression speed by using the *Show Window Info* command available in the *Options* menu (on the Remote Video window); if it's slow you can deselect this option and use the CPU to decompress jpeg streams. This option is available only on LoLa "_Cuda" versions.

- **"Incomplete frames rendering threshold"**: when using uncompressed video you can also select the incomplete frames rendering threshold (Fig. 5); 0% means that Lola must receive ALL video packets from the remote host in order to correctly render the entire video frame. Setting a percentage between 1% to 10% means that LoLa can render the video frame also if it hasn't received all the necessary packets to rebuild the entire frame: in case of some lost network packets, this results in small black lines randomly rendered on the display surface. In normal operation conditions, there shall be no lost data packets, thus this parameter shall be left 0% (which is the default value). Use it only if you experience some small network problems which affects video.

4.1.3 Network Setup

Starting from version 2.0.0 you will find only Video packet size and IP and UDP Advanced Filtering. These settings are only for advanced configurations, **so leave them to the default value** (1000 bytes for the first one and “checked” for the second one).

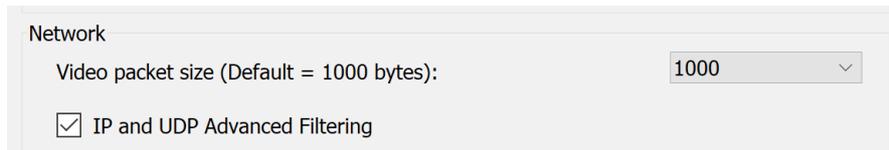


Figure 6: Lola Setup, Network section

4.2. Local and Remote rendering windows

The features of the local video stream (resolution / pixel depth / frame rate) are shown on top of the video frame, as shown in Fig. 8 (i.e. “Local host: 1280x1024, 24 bit, 30 FpS”).

It is possible to enlarge the video frame by selecting the desired zoom ratio from the pop-up menu (right click) available on the video frame (Fig. 7) or simply by resizing the window with the mouse; note that the video aspect ratio is preserved in all cases. *Since version 1.4.0 there are no more problems about CPU usage because video rendering is completely Gpu accelerated.*

You can monitor window rendering speed and overall video performance by using the *Show Window Info* command (Fig. 7) available in the pop-up menu. When you select this option, you will see some useful information (Rendering mode, FpS, Zoom, Bayer decoding speed, Rendering speed, Jpeg compression/decompression speed) overlaid on your display surface (Fig. 8).

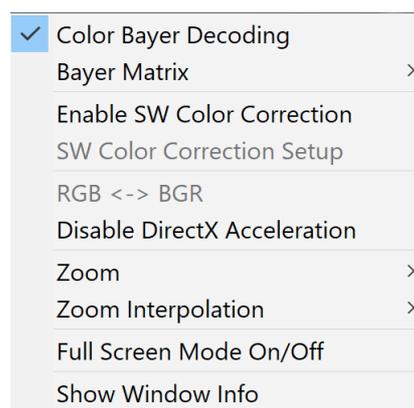


Figure 7: local/remote windows right-click pop-up menu

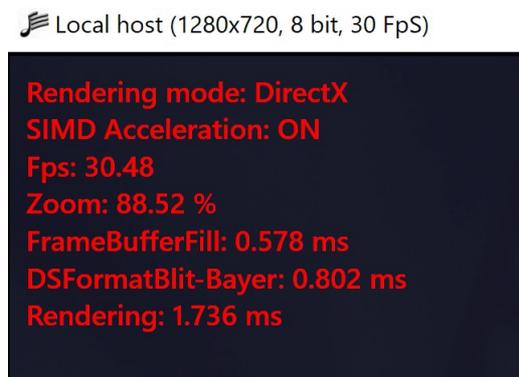


Figure 8: Rendering info overlaid on display surface

4.3. Color Menu and Bayer decoding

“Color Bayer Decoding” and “Bayer Matrix” menus, available in the local/remote window pop-up menu (Fig.7), are intended for use with digital cameras when 8 bit Bayer encoded images are used (Raw8/Mono8): they allow to switch from B/W to Color (by software Bayer decoding) and to select the correct Bayer matrix type.

If you experience some strange color artifacts, try to change the bayer matrix type: for example the Ximea xiQ cameras use “BGGR” and the Ximea xiC use “RGGB”.

“Enable SW Color Correction” command available in the pop-up menu provides support for color corrections (both for demosaiced and RGB images); this is a software correction and so use it carefully because it adds some amount of latency depending on your CPU speed. Note that when digital cameras with an RGB 24bit pixel depth are used, this option is automatically disabled because LoLa can directly control the color corrections through hardware interface and with no latency. In this case use the “Digital Cameras HW Color Correction” command available in the main window “Options” menu (Fig. 9).

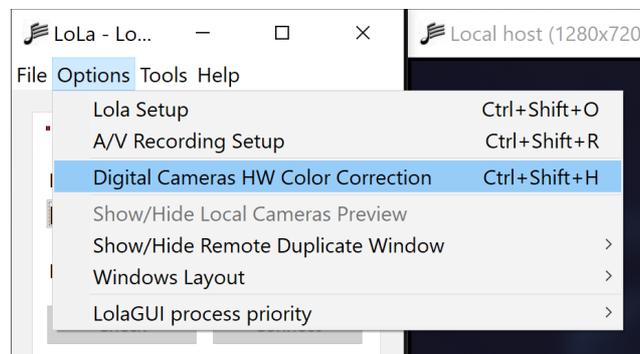


Figure 9: Hardware Color Correction command

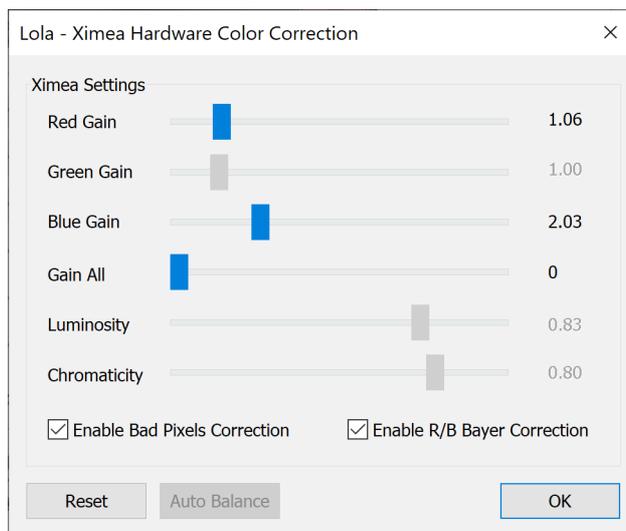


Figure 10: Hardware Color Correction window for Ximea xiQ cameras

Depending on the camera pixel format (Mono8 or RGB), some color correction options may not be available.

For the Ximea digital cameras are also available the following options (Fig. 10):

- **“Enable Bad Pixels Correction”**: in accordance with the manufacturer's specifications “this correction is done on the host side (driver level), based on the RAW data received from the camera. This means that the processing is an additional step in the imaging pipeline, but its impact on the overall latency is really marginal (it uses SSE function set)”. However, in order to ensure the maximum LoLa performance, this option is disabled by default;
- **“Enable R/B Bayer Correction”**: starting from version 1.4.2, you can correct the Red/Blue dominance for the Mono8-Bayer encoded video format and this is done before sending your local video stream to the remote host. The color correction is processed internally by Lola using SIMD accelerated instructions and it requires a very short time (of course depending on your cpu performance): i.e. for a Full-HD image, on an Intel i9, octacore processor, it takes about 0.4 ms. This option is disabled by default. ***Since Ximea cameras have a green color dominant, you can generally obtain a good color balance using the following settings: red at 1.1 and blue at 2.0.***

NOTE: *In order to reduce the required network bandwidth, it's highly recommended to use Bayer encoded images; when demosaiced they have the same quality as the RGB ones and generally the overall latency added by decoding process is about 0.6 ms or less (Intel Core i7 or i9, octacore).*

To use Bayer encoded images on digital cameras, simply select a camera-file with “Mono8” indication in the *Camera Settings* drop-down list (i.e. “1280x720-**Mono8**”). LoLa will automatically activate the “*Color Bayer Decoding*” command menu.

4.4. Connection with a remote host

The simplest way to connect to a remote host is by specifying its IP address in the *Remote IP Address* box and clicking on the *Connect* button.

You may also load a previously saved “Session Configuration File” in which the address information for a given host is stored. These are files with extension *.ssn* , and can be loaded/saved using the *File* Menu (Fig. 11). These files are stored into the same folder where the LoLa application is. The configuration stored into the “LastSsn.ssn” file is always the settings used in the last LoLa session. If you want to create your own LoLa address/configuration book, just create one *.ssn* file per each site you usually connect to, and then recall the appropriate one when needed. To remove a stored session configuration, just delete the corresponding *.ssn* file in the LoLa folder.

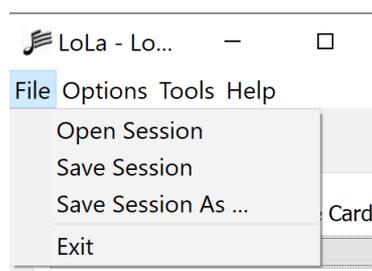


Figure 11: Session Load/Save options

Before sending a connection request, it is recommended to check if the remote host is ready for the connection. After inserting the remote host IP address, use the *Check* button provided in the control panel below the IP address box: LoLa will issue a “ping request” the remote host at the given IP address, and will also check if LoLa is running on it. An estimate of the network round trip time (RTT) will also be provided. If the remote host is reachable, but LoLa is not running on it, you should ask your remote party to start LoLa on his local host, and wait until your *Check* test declares LoLa is also running remotely. The LoLa chat service (see section 4.10) works after you enter the remote IP address and can help you in coordinating the connection with your remote partner. Please note that if ICMP network protocol is filtered by network or local firewalls, the “Check” test will fail, but you may be able to correctly “connect” anyhow.

If LoLa is running on the remote host, pressing the *Connect* button will cause the two systems to negotiate the connection and start sending their audio/video streams to each other. Only one node needs to initiate the connection. Note that while different video stream characteristics are allowed for the two hosts (e.g., different frame rate, picture resolution, bit depth, color or b/w), **the audio stream parameters must be exactly the same**. By default, 44100 Hz @ 16 bit, stereo, is assumed. If during the negotiation an incompatible setup is detected, the two hosts will refuse to connect. This is particularly important if audio multichannel is enabled.

4.5. Fine Audio/Video buffer tuning

Once the two or three hosts are connected, the user will have the opportunity to interactively change the number of audio and video buffers used by the application, by using the *Buffer Tuning* settings available in the “Remote Buffers Tuning” section of the main window (Fig. 12). The number of buffers can be set using the control slider or the keyboard arrows. Adding buffers means also adding latency: this fact indeed also let you fine tune the audio/video synchronization, for example by adding audio buffers. A balance between optimal latency, quality and synchronization is something you should try to achieve, depending on the specific configuration situation.

The number of buffers can be increased if dropouts or glitches are noticed in the received audio or video streams, due to network traffic or delay jitter, otherwise it should be kept as low as possible to avoid additional latency. In a typical correct situation video buffers are set to “0”, and audio buffers should be possibly “0” and not exceed “5”. LoLa remembers the last settings of all Audio and Video Buffers, and will also save them into all specific *.ssn* files you save; thus you can also save the “ideal” settings you like for any remote location you connect to.

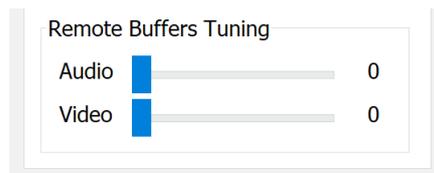


Figure 12: Buffers tuning section

4.6. Toggling Audio/Video and Network Monitor

During a connection, the user can also gain some information on the audio and video stream through the Network Monitor panel, available in the *Tools* menu (Fig. 13). This dialog box provides some information on the connection and on the traffic, as well as the possibility of selectively switching off/on each one of the inbound, outbound, audio and video streams.

The *Network Monitor* windows Video section also show real-time values of send/received video frames: “Local window Fps” and “Sent Fps” shall always be close to “Local Fps settings” values. At the same time “Remote windows fps” and “Received Fps” shall always be close to “Remote Fps Settings” values. If you notice quite different values, you should start investigating for transmission losses problems (differences in Remote values) or in local PC performances (Local values).

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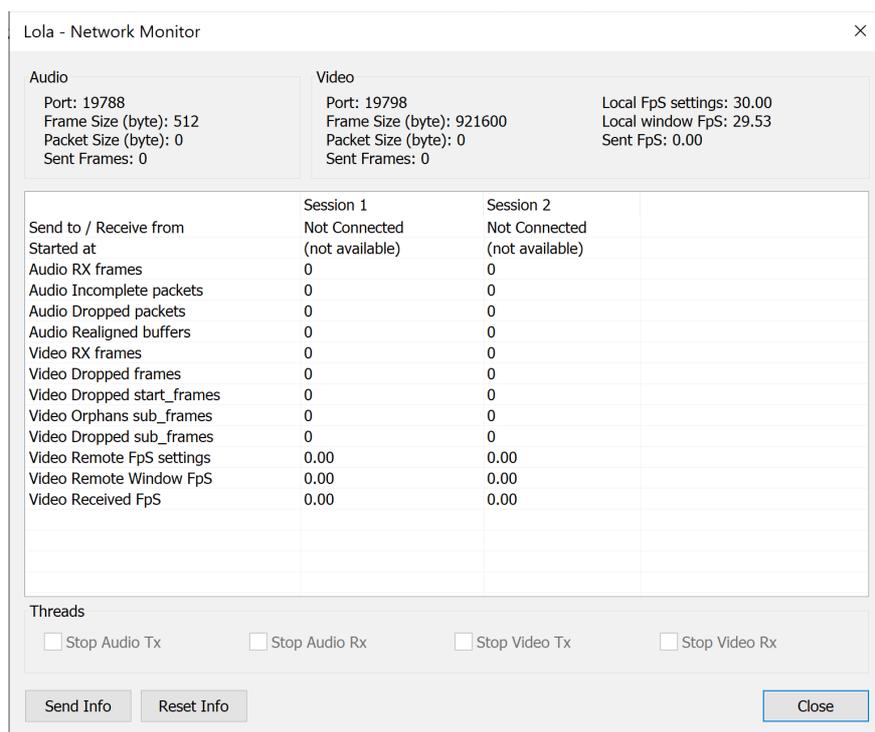


Figure 13: Network monitor window

4.7. Disconnecting from a remote host

The connection can be interrupted by any of the hosts by simply clicking on the *Disconnect* button.

When the software is shutting down, the current local configuration (i.e., audio and video setup) will be saved to a *.ini* file located in the same directory as the executable, and will be loaded at the next start-up of the LoLa application. Also, the last session information (remote host address and info) is stored for future sessions.

Please note that if a session does not disconnect properly (for example due to a network failure or an application or PC unexpected crash), the remote node may remain “in hang mode” still sending its streams. In such a case the remote PCs shall manually force a disconnect, with the disconnect button.

4.8. Debugging a connection: Bounce-Back mode

Starting from version 2.0.0, bounce back mode is no more supported.

4.9. Debugging a connection: TaskMgr

LoLa strictly rely on an error free stable network connection. To check the status of what you are sending/receiving from your own PC, you should run the Windows “TaskMgr” application.

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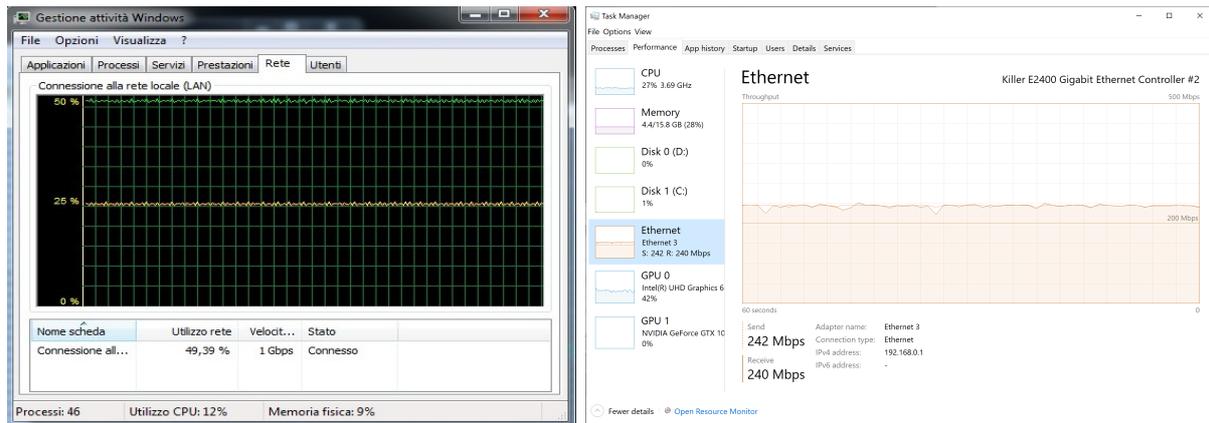


Figure 14: Windows Task Manager

Select the “network” tab, and under the “show” menu display all total (green), input (yellow) and output (red) real time traffic statistics (please note that the TaskMgr window look depends on the Windows OS version, but they all display the same information). When everything is working fine (with uncompressed video - default) you should see something like the above picture: a very stable constant traffic flow, both in and out. If the 2 nodes are configured in the same way (same frame rate, same resolution, same number of audio channels, etc) the input and output traffic shall be very close to each other. If you see that the input traffic is unstable (and of course LoLa loses lot of audio and video data), your should start investigating the network setup. It means that at some point of the connection between the remote sending node and your node traffic is dropped. This can happen in the various places: the network backbone connections (check with your network supplier), or on the remote Local Area Network (check with the remote partner) or in your own Local Area Network. In case of LAN problems, check that you do not have any firewall of any kind in place on the LAN, because most of them cannot cope with LoLa traffic correctly. You should also check that your LAN switches can work with LoLa traffic (at 30000 Packets Per Second PPS for 30fps in color SD), and in case check if you have any IP traffic shaper in place which can affect LoLa traffic, too. If you are running in video compressed mode, then the traffic pattern varies, as it depends on the amount of changes which happen in the video images.

4.10. Audio and Video Recording

4.10.1 Audio recording

LoLa can record an audio session at full quality, both for the local and the remote audio. If you specify a file name and press the “Start Now” button on the main window, LoLa will create into specified folder 2 audio files, with “_Local” and and “_Remote” suffixes which contains all audio channels being send/received during a session. Please note that if you use more than 2 audio channels, the audio recording files will contain all audio channels, thus you need an appropriate audio player/editor in order to be able to open them all. Inside LoLa folder you will also find

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LolaWavSplitter.exe: it's a small utility to extract channels from a multichannel .wav file (see “LoLa Tools” chapter for more details).

4.10.2 Video recording

Starting from version 1.4.0, LoLa can also record video sessions (both local and remote streams).

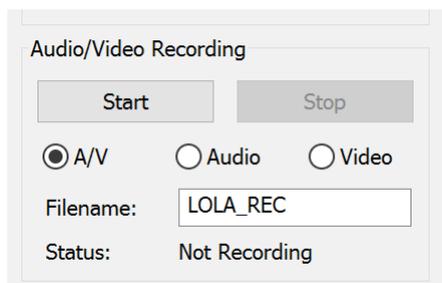


Figure 15: Audio/Video Recording Section (main LoLa window)

In the “Audio/Video Recording” section of the main window, you can Start/Stop recording, select which stream to record (both Audio and Video, Audio only or Video only) and set the output filename. To select the output path or to change the default recording settings select the “A/V Recording Setup” command available in the main window “Options” menu or simply press Ctrl+Shift+R. Please refer to the following section 4.9.3 for further details.

Note: When recording uncompressed data, please pay attention to your hdd/sdd writing speed. For example the required bandwidth for an uncompressed 1920x1080 RGB video stream at 30 fps is about 178 MB/s and recording both local and remote streams on the same disk raises it to 356 MB/s. Using a Bayer encoded video with the same resolution and fps reduces the bandwidth demand to 59.33 MB/s or using Jpeg compression drastically reduces it to about 7 MB/s or lower (depending on compression quality). To achieve better performance it is also suggested to use different physical disks for recording local and remote streams.

LoLa writes the video streams to disk as a sequence of numbered image files (one file for each frame) using bmp or jpg formats; this system should grant a good compatibility with general video-editing softwares.

Remember that the main function of LoLa is to guarantee the perfect stability of the audio and video stream, so recording is a secondary background process; therefore it may be that LoLa cannot correctly record all audio/video frames and it cannot guarantee that the video recording will be perfectly in sync with the audio one (drop of packets, realigned buffers, et. can cause loss of information). The recording feature of LoLa is intended as a simple support to the session and it cannot substitute a professional recording of the event/performance.

4.10.3 Audio and Video Recording Setup Window

Inside “A/V Recording Setup” window you can change various recording settings. You can specify the output paths, compression (uncompressed or jpeg compressed images) and decide which stream to record (local, remote or both).

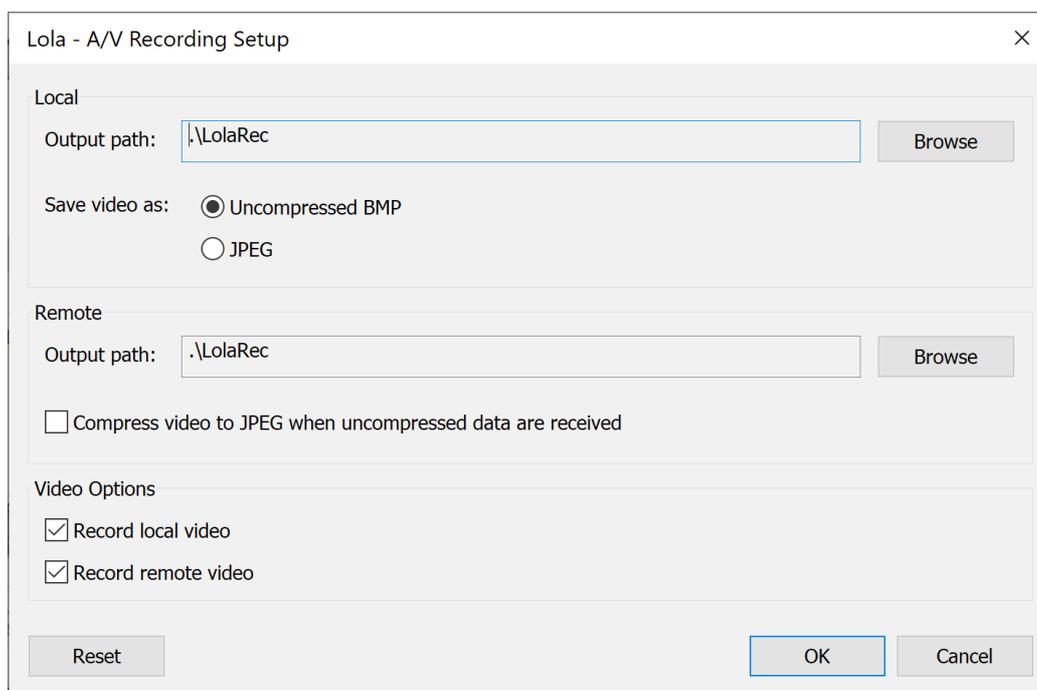


Figure 16: Audio/Video Recording Section (main LOLA window)

4.11. Chat window

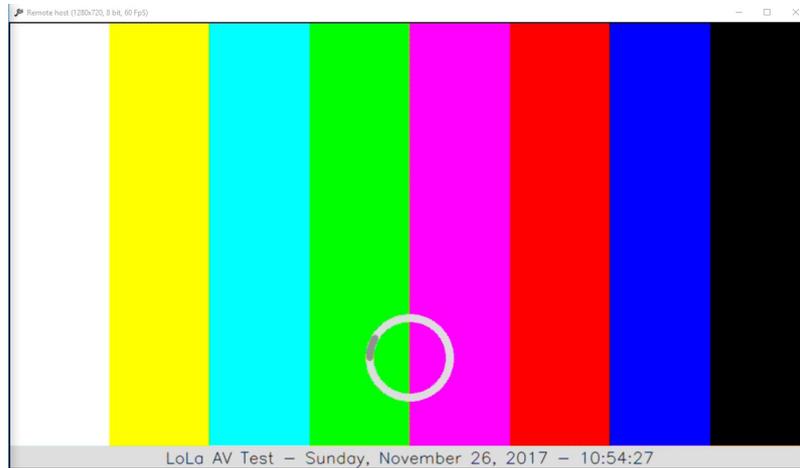
In order to resolve possible issues with the remote host, LoLa has the ability to “chat” with the remote node. To open the chat window select the *Chat window* command available in the *Tools* menu or simply press Ctrl+L. The remote address where the message will be sent is the same as that indicated in the main window in the *Remote Session/IP Address* field. To send the message press CTRL+Return. Chat window works also when LoLa is not connected.

4.12. Audio/Video Test signal

To test the audio connection, LoLa can send/receive an internally generated audio signal

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(689Hz/750Hz, -12dBfs) and video signal (SMPTE color bars) to/from the remote host. To do so use the *Send AV Test Signals* or *Receive AV Test Signals* commands available in the *Tools* menu. *Until v1.4.x only the audio signal is generated, and at -6dBfs.*



4.13. Windows layout

When LoLa is connected to the remote host, you can decide how to automatically dispose the Local and Remote windows on the screen. Three layouts are available: tile vertically (Ctrl+Shift+1), tile horizontally (Ctrl+Shift+2) or maximize remote (Ctrl+Shift+3). This last is really useful when using HD or Full-HD setups. When using multiple cameras and/or connecting to 3 sites, it may be better to manually adjust video windows on your screens.

4.14. Duplicate window (remote host display)

When LoLa is connected to the remote host, you can duplicate the Remote host window by clicking on the *Create/Destroy Duplicate Window* command available in the main window *Options* menu. A new remote window clone will be displayed; to destroy it simply click another time on *Create/Destroy Duplicate Window* command.

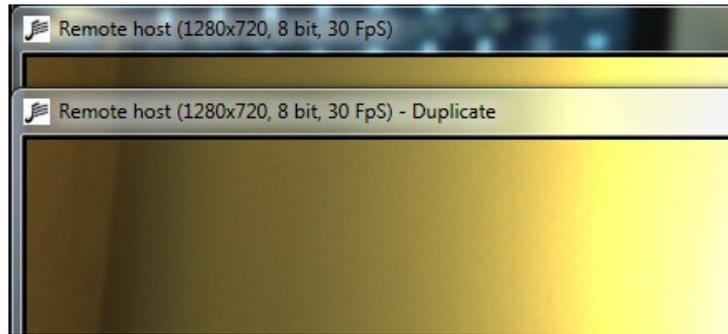


Figure 17: Duplicate window (remote host)

Duplicating the remote windows is useful to organize your local video setup, enabling scenarios where you need to handle in different ways the video coming from the remote site. For example imagine that you need to use a monitor dedicated for the users involved in the connection, and you need another different image to display to the audience on a different screen or projector. As you can zoom/resize independently the 2 video windows, you can arrange them in the more appropriate way for your setup.

4.15. LolaGui process priority

Starting with version 1.4.0, you can change the LolaGui executable process priority by using the “*LolaGUI process priority*” menu in the *Options* menu (main window).

In the previous versions it was hard coded and set to “High priority” by default; but after adjusting and improving some internal thread settings, LoLa can now work with a “*Normal priority*” level. This change has brought some benefits for the audio thread stability, specially when using HD video streams and/or CUDA acceleration (it primarily avoids some audio “click” issues).

You can try to raise the priority level to “Above Normal” or “High” and see if this could improve your LoLa performance or not; it highly depends on your CPU type, speed and number of cores.

4.16. Show/Hide Local Cameras Preview

Since v2.0.0 Lola can use up to 4 local cameras. When using a multiple cameras setup, you have the ability to visualize the RAW (B/W) preview of the cameras inside a window. To switch between available cameras just use the 4 buttons of the “Local Camera” section of the main window. At the moment the camera selection cannot be done from remote (local selection only).



4.17. Audio only setup

If you haven't installed a camera on your system, you can use LoLa in an "audio only" setup. During start up, LoLa will warn you about no video devices found and ask you if you want to continue; answer "yes" and you are ready to go.

4.18. LoLa status checking suggestion

See a number of suggested checks while you run LoLa:

- If you have more than one network card, make sure to select the right one (the one really connected to your network and correctly configured); otherwise LoLa could fail to connect or show you a black "Remote host" window. See section 4.
- After applying your camera "Fps" setting, always check it is set correctly by opening the LoLa Network Monitor (*Tools* menu → *Network monitor*) and look if the "Local FpS settings" and "Local window FpS" values match.

You can also check it by using the "Show Window Info" command in your "Local host" window context menu; when selected a "Fps" info will be overlaid on the display surface (together with other useful information).

- When selecting a camera file and the relative image size and pixel format (Mono8 or RGB), please take a look at the estimated TX bandwidth value in order to avoid sending too much data and packets to the remote host (this can cause video stuttering or audio crackling noise issues to the receiving site).

5. LoLa Tools

Provided with LoLa there are three useful tools: LolaWavSplitter, LolaVideoConverter and LolaGui_Tester.

5.1. LoLa Wav Splitter

This tool converts multichannel audio files into separate mono files.

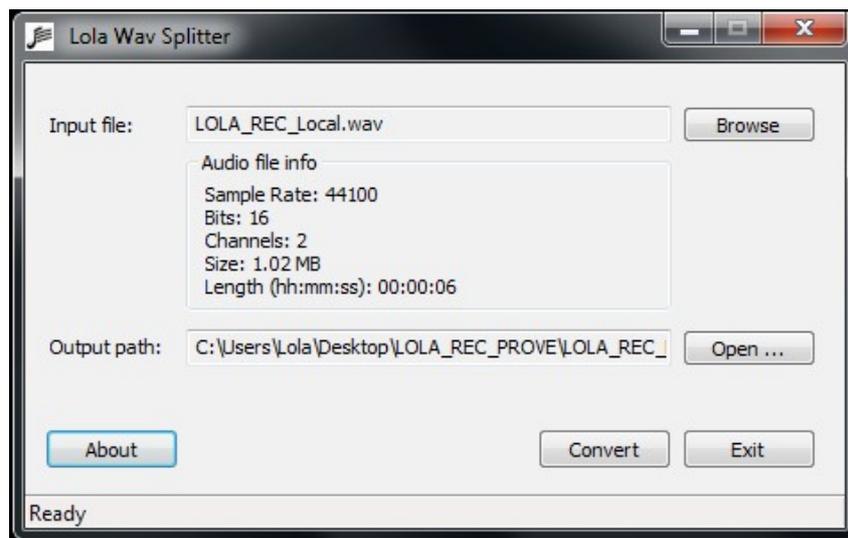


Figure 18: LoLa Wav Splitter application

5.2. LoLa Video Converter

In order to optimize the overall system performance, LoLa writes raw image files when using Bayer encoded streams or Jpeg BGR files when using compressed streams. So, before importing these files into your preferred video editing software, you can use this tool to convert them into one of the following formats:

- 8 bit Bayer encoded to 24 bit RGB;
- BGR to RGB (for 24 bit Jpeg compressed images)
- Uncompressed Bmp to Jpeg;

Using "Browse" button you can specify the folder where you previously saved the A/V files; in the Files info section it will display the total number of video files, their format (bmp or jpg) and image info. It also suggests the more appropriate conversion option.

Click on the "Preview" buttons to have a conversion preview based on the first captured frame.

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Clicking on "Convert" button will start the conversion process. When finished you will find the converted files in the same "Input path" location but inside a newly created folder named "ConvertedFiles_[DD_MM_YY]_[hh_mm_ss]" (where DD=day, MM=month, YY=year, hh=hours, mm=minutes and ss=seconds). Files inside new folder maintain their original name.

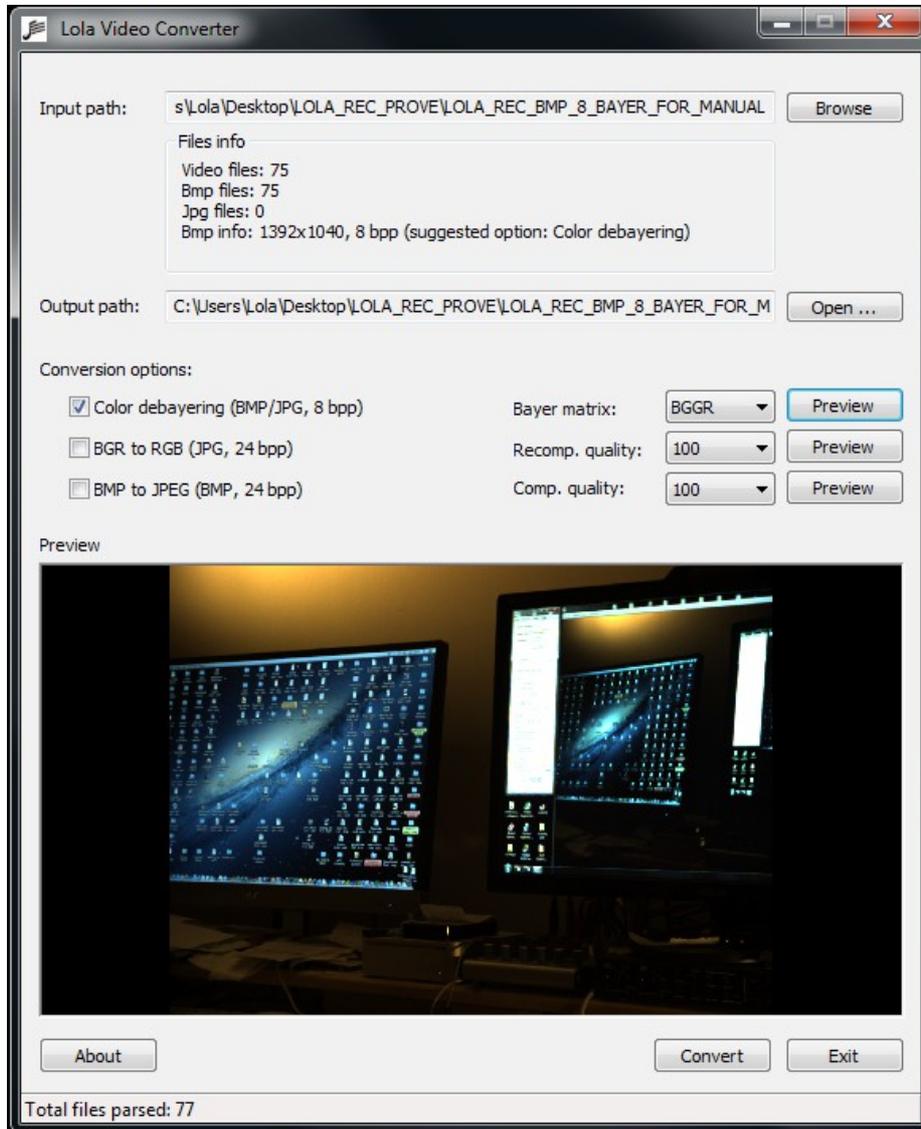


Figure 19: LoLa Video Converter application

5.3. LolaGUI Tester

This tool simulates a LoLa setup which runs without audio and video equipment, but generates a nearly identical network traffic as the real LoLa does. Currently it only generates a video data stream, because is really difficult to emulate the RME Audio cards internal

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clock/interrupts precision; but given the large network traffic is generated by video stream it works fine as a quick to use tester for the network capabilities.

You can use it to connect between two "tester" installations, but NOT between a real LoLa application and a tester.

Since version 1.0.3 there are a jitter indication and a jitter graph in order to get more detailed info about your network performance.

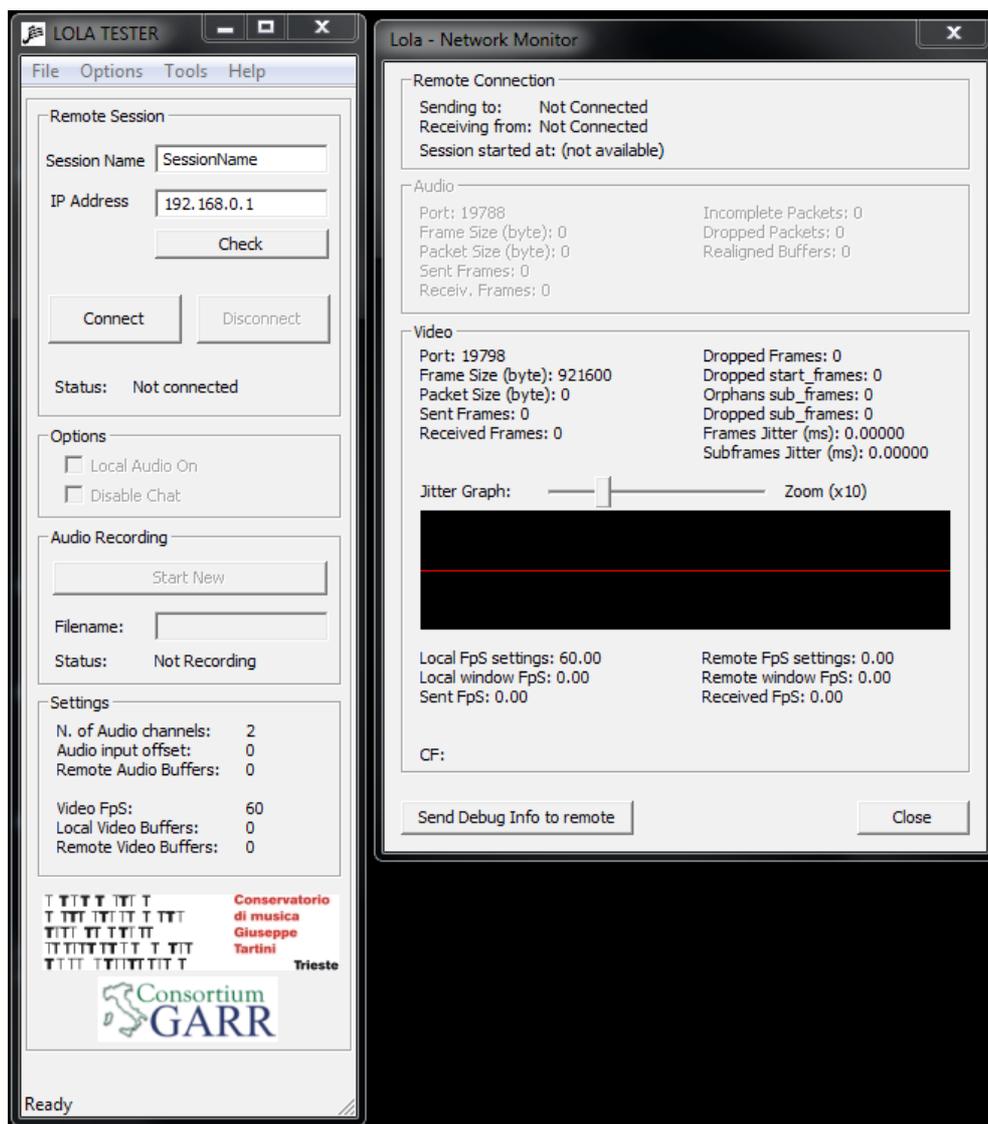


Figure 20: LolaGUI tester application

Appendix A – Old analog and digital video setup

There is NO MORE support for this kind of video setup and for analog cameras!

Appendix B – Audio Card internal Mixer settings

LoLa usually adopt **RME audio cards** for audio in/out functions. In order to work correctly, these audio cards must be setup in the correct configuration to ensure LoLa gets the correct audio input channels, and also can output the sound from the remote host correctly. You should at first display the audio card routing matrix (see Fig. B1 and B2). The top row displays the available input channels. This information is useful to set appropriately the AudioInputOffset parameter. In both examples, to use AN1 and AN2 analog channels the AudioInputOffset must be set to 0; to use the ADAT A1...A8 channels, the AudioInputOffset must be set to 8 in the Fig. B1 example, and to 4 in the Fig. B2 one.

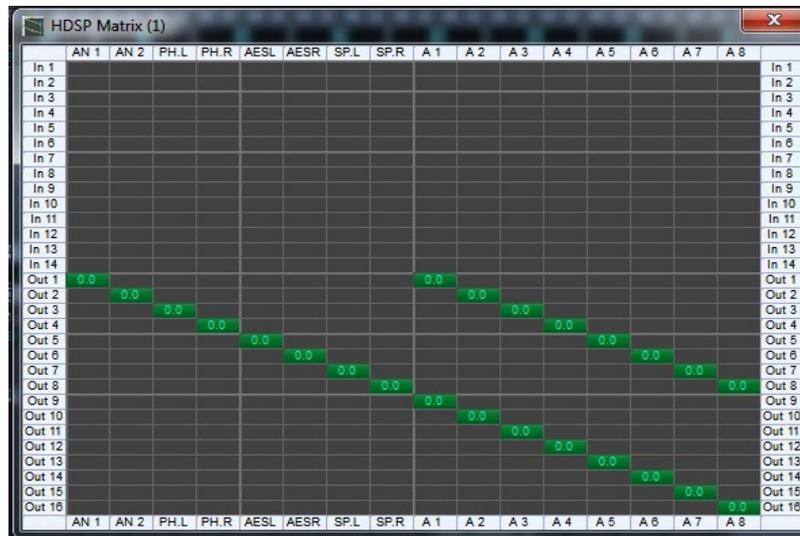


Figure B1: the HDSP Matrix, with audio out routing for analogue and ADAT channels

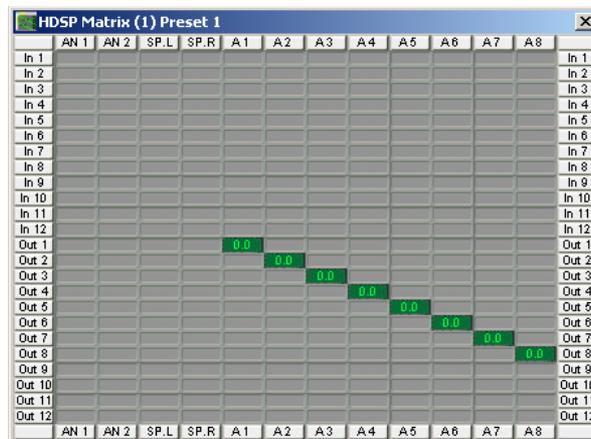


Figure B2: a different HDSP Matrix, with audio out routing for the ADAT channels only

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Then the output routing shall be correctly configured. Fig. B1 shows a correct routing example both for the analogue channels and for the ADAT channels. Fig. B2 shows a configuration where only the 8 ADAT channels are routed to the output.

The HDSP audio Mixer should also look like in Fig. B3 or B4. Please note that buttons link Out1 Out2 AN1 AN1 shall NOT be in red/pink color, because this means you set the audio card in local audio loop.

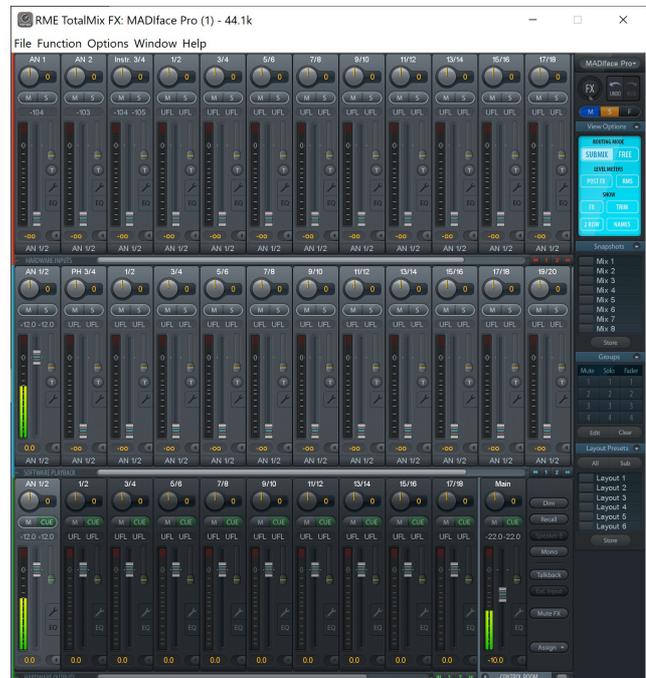
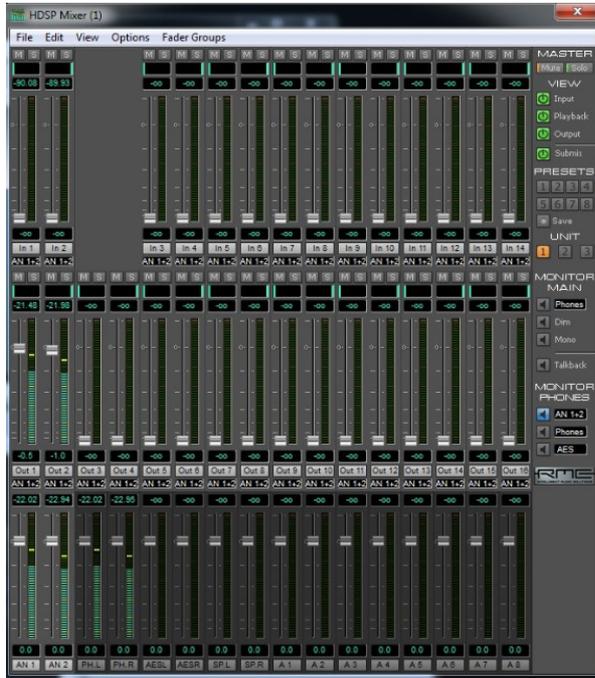


Figure B3: The RME main Mixer window (stereo analog in/out setup)

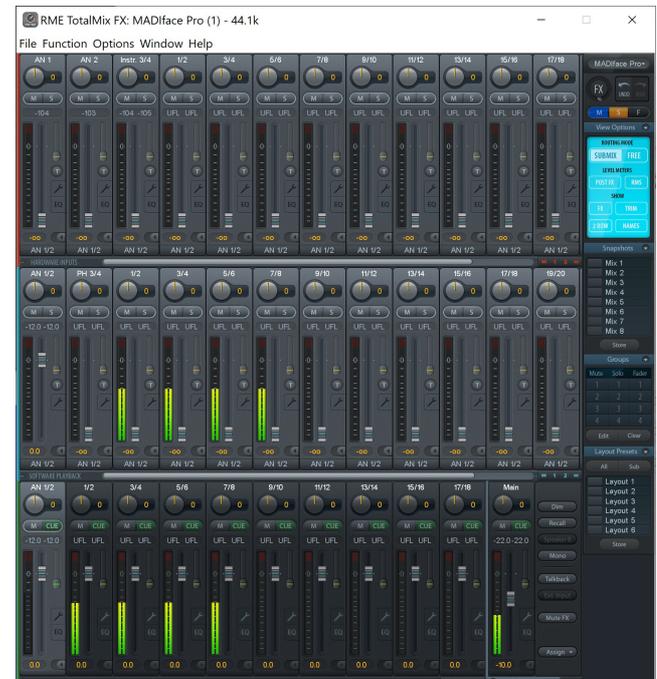
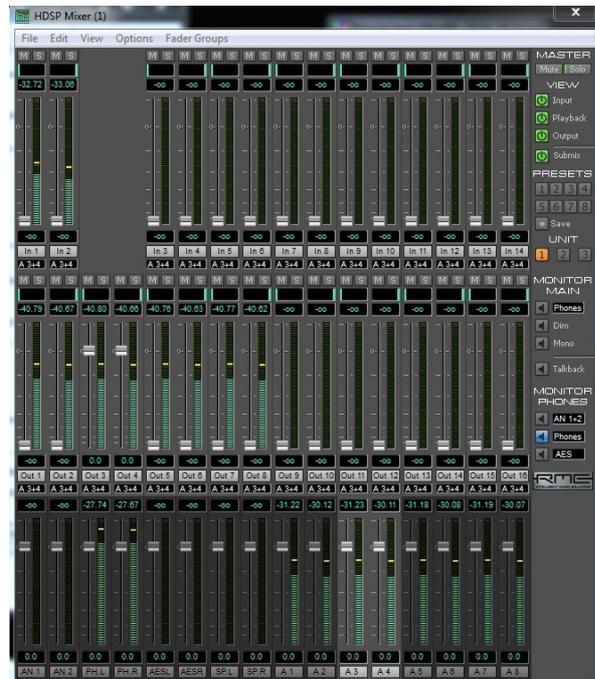


Figure B4: The RME main Mixer window (8 channels out setup)

Appendix C – LoLa Hardware components

HIGH-END PC (Full HD resolution, 1920x1080, RGB):

- Mid/Full tower case with quiet design, a good air flow circulation and fans, and at least four full height expansion slots (Antec Sonata Solo II or P110 Silent or similar)
- Power Supply Unit: at least 860W (Corsair AX860i or better)
- Processor: Intel Core i7 or i9 (8 cores or better) with a good and silent water cooling system (Corsair Cooling Hydro Series H115 or similar)
- 16GB RAM DDR4 (Corsair or Kingston, 4x4GB, Quad Channel DDR4 Memory Kit)
- Motherboard: an high-end motherbord with **Intel chipset X299** or better (**ASRock or Asus motherboards are highly recommended**) with enough PCI-express slots for:
 - 1 Graphics Card (16x slot required) - Note: high-end graphics cards occupy the space of two slots!
 - 1 USB3.0 adapter card in case the motherboard has an incompatible USB3-Vision chipset
 - 1 RME Audio Card (for the HDSPe-AIO a 1x slot is required)
- SSD (suggested for OS)
- 2 HDD - 1TB (Raid 0 configuration) for uncompressed video recording (Western Digital WD-Black)
- Nvidia GeForce GTX 980 or better (EVGA) - suggested for jpeg hardware acceleration
- Intel Gigabit CT Desktop Ethernet Pci-e adapter (**required when an Intel NIC is not integrated on the motherboard**)
- Full-HD LCD Monitor with low response time ($\leq 1\text{ms}$)
- OS Windows 8.1 or 10 (64-bit)

MID-RANGE PC (SD/HD resolution, 1024x768, RGB):

- Mid/Full tower case with quiet design, a good air flow circulation and fans, and at least four full height expansion slots (Antec suggested)
- Power Supply Unit: at least 500/600W (Corsair suggested); it depends on Graphics card
- Processor: Intel Core i7 (6 cores)
- 8 GB RAM DDR3 (Corsair or Kingston suggested)
- Motherboard: a mid-range motherbord with Intel chipset and enough PCI-express slots for:
 - 1 Graphics Card (a 16x slot is required) - Note: high-end graphics cards occupy the space of two slots!
 - 1 USB3.0 adapter card in case the motherboard has an incompatible USB3-Vision chipset
 - 1 RME Audio Card (for the HDSPe-AIO a 1x slot is required)
- Nvidia GeForce GTX (suggested for jpeg hardware acceleration)
- Intel Gigabit CT Desktop Ethernet Pci-e adapter (required when an Intel NIC is not integrated on the motherboard)
- OS Windows 8.1 or 10 (64-bit)

GAMING hi-end Laptops

LoLa is currently under test also on some hi-end GAMING laptops. Here is an example:

Dell G5 15 - 5587 Gaming PC with the following internal configuration:

- 8th Generation Intel(R) Core(TM) i7-8750H Processor (6-Core, 9MB Cache, up to 4.1GHz with turbo boost)
- 15.6-inch UHD (3840 x 2160) IPS Anti-Glare LED-Backlit Display
- Non-Touch FHD UHD Back Cover - Matte Black
- 16GB, 2x8GB, DDR4, 2666MHz

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- 512GB Solid State Drive
- 1TB 5400 rpm Hard Drive
- NVIDIA(R) GeForce(R) GTX 1060 with 6GB GDDR5 graphics memory
- Windows 10 64bit English

The laptop has an internal Killer Ethernet E2400 NIC which already performs well enough, but an external NIC (via USB-C interface) is also suggested, like the USB-C to Gigabit Network Adapter with Extra USB 3.0 Port Startech.com part number US1GC301AU. Tests are ongoing also with the external USB-C Thunderbolt3 10GBASE-T Network Adapter OWC part number TB3ADP10GBE. You will also need one external Firewire or USB RME audio interface (see Audio Cards below).

- USB3Vision Digital Cameras (no frame grabber required)

- XIMEA MQ013CG-E2 camera or MC023CG-SY (all xiQ and xiC Ximea cameras are compatible with LoLa and are at the moment the most performant suggested video h/w).

- Internal PCIe Audio Cards:

- RME HDSPE-AIO or RME MADI FX

- External Firewire or USB Audio Cards:

- RME Fireface 400 and 800 (Firewire) or Madiface and MADIFace Pro (Usb)
-

- Possible Audio Components

- 2 small Genelec or Yamaha audio monitors
- 1 active audio PA system (for example Mackie)
- 2 condenser high quality microphones (for example Neumann KM184)
- 1 dynamic microphone (service voice)
- 1 analogue mixer (minimum 16ch in, 4 out + Main L/R, 4 AUX - for example Mackie) or a better one digital mixer with ADAT support (for example Yamaha 01v96i)
- Various audio cables

*For further details and for an updated components list you can also take a look at LoLa website:
<https://lola.conts.it>*

Appendix H – Known Issues

H.1 No timeout on remote partner unexpected disconnection

In some rare occasions, if the remote LoLa system occurs in an unexpected disconnection (system or application problems, network disconnection, etc) and thus cannot notify the other system about its closure, the local system remains “open and active” without warning (you of course immediately see you are not receiving any more audio/video from the remote system). In such a case, just quit LoLa manually and restart it to be ready for a new connection. If the remote system resumes transmission without requesting a new “connect” (for example because it has been a network disconnection problem), both LoLa systems will realign and restart normal operations without any action needed by you on both sides. If

H.2 Windows Firewall and LoLa initial “check”

Windows 7 Firewall by default completely blocks ICMP (“ping”) packets. This makes the initial LoLa “check” function unable to work correctly. To ensure that you can correctly use LoLa, without risking to run with a Firewall completely disabled (if you are on the public Internet), you should configure Windows Firewall with a rule enabling ICMP packets flow on your system (as well as on the remote system, of course).

H.3 LoLa and antivirus software

LoLa uses an IP network packets building engine based on WinPcap libraries. Many antivirus packages will detect this and list LoLa as a “malicious” software and try to block it. Until these antivirus software will correctly recognize LoLa, you should disable them on your system. More over, in any case, antivirus packages perform highly invasive activities on your PC, which can seriously compromise system performances and LoLa itself. Thus you should carefully disable them while using LoLa.

H.4 Packet Per Second (PPS) and LAN Switches

LoLa produces a very high UDP packet per second (PPS) rate, especially when in color mode at 60fps. A number of LAN switches might be unable to cope with such a traffic, especially if there are other applications running on the same switch which also requires a high PPS rate or packets priority handling (like VoIP system/telephones, etc). If you see, for example via TaskMGR “network monitoring” application a very irregular traffic pattern (and you get audio/video drops, clicks, artifacts), try to disable other applications running on the same switches, or try to setup a direct connection between the LoLa system and your border router, avoiding the LAN switches which cause the problem.

H.5 Packet Per Second (PPS) and NICs

Network Interface Cards (NICs) based on Realtek, Broadcom and some on Maverick chipset cannot deliver correctly the PPS rate required by LoLa. This issue is know also when these NICs are used for other kind of applications and depends on the the way the NIC drivers are handling traffic. There is no workaround

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to this issue until the manufacturer fix it either in the NIC itself or the drivers. We suggest to use Intel based NICs which work fine. Please see some important informations about “Interrupt moderation rate” settings for the Intel NICs described at chapter 2.8. *Network Interface Cards (NICs) performances*.

H.6 Network Configuration on the same Virtual LAN (for previous LoLa versions before 2.0.0)

This issue has been fixed in LoLa v2.0.0; configure Network in standard way also on VLANs.

H.7 Video Artifacts if LOCAL and REMOTE video windows overlay on screen.

If the LOCAL and the REMOTE video Windows overlay one to the other on the screen, the foreground window may display some artifacts in the area where the background window is laying behind it. This issue is still under investigation. Thus avoid to have partially overlapping LOCAL and REMOTE windows on the screen while using LoLa. The issue is not present if one of the windows uses the full area of the screen.

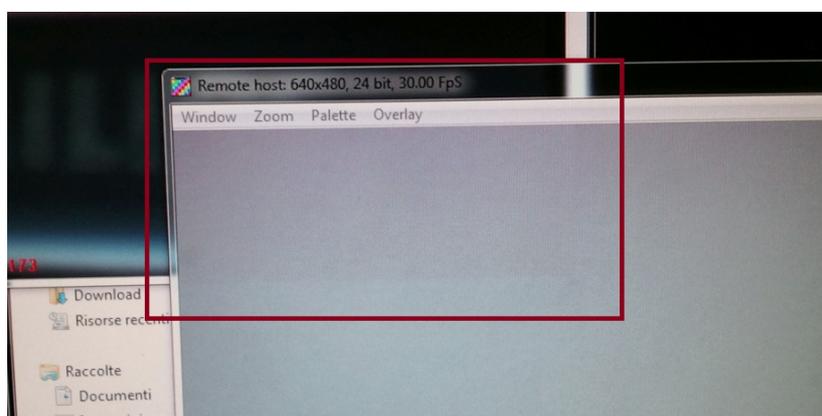


Fig H1: note the artifact in the area where the 2 windows overlap (in this case a different color rendering, but it can also be a partially late frame area).

H.8 Manual installation of the “Microsoft Visual C++ 2010-2019 Redistributable Package (x64)”

In case you encounter any issues with the included Microsoft libraries, you can manually download and install the package from:

<http://www.microsoft.com/en-us/download/default.aspx>

and searching for "*Microsoft Visual C++ 2010-2019 Redistributable Package (x64)*". In case you can also apply the appropriate security patches, if any.

H.9 Digital cameras initialization failure when using the GenICam interface

There is no more support for GenICam interface.

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H.10 Digital cameras bayer encoded images (Mono8/Raw8)

If you experience some strange color artifacts, try to change the bayer matrix: for example the Ximea xiQ and Imperx cameras use “BGGR”, Ximea xiC “RGGB”, and instead the PointGrey use “BGGR” for Flea3 cameras and “GRBG” for the Grasshopper3 ones.

H.11 Audio/Video recording

When recording Audio and Video streams, it can occur that the two streams may not be synchronized. At the moment LoLa recording feature is not intended to be precise, because our goal is to maintain the main AV network stream stable and balanced, without any delay, so at the moment it's normal to have some issues about synchronicity between recorded AV files. In the next future we're going to rewrite the code in order to sync them better and probably by inserting a timecode feature in both audio and video files.

Appendix I – Remote assistance with TeamViewer or VNC

In order to give you a better assistance or to configure untested digital cameras, LoLa support team can also check and debug your PC and camera remotely using the TeamViewer or VNC software. Before asking for remote assistance, please download the “**TeamViewer QuickSupport**” executable (**please make sure to download the “QuickSupport” version and not the full TeamViewer installer**; the TeamViewerQS.exe is a simple standalone application that doesn't require any installation).

As an alternate, you can also install **TightVNC** to let the support team connect to your PC. TightVNC has the advantage to consume much less PC resources, so it also allows to run LoLa connections while the PC is under remote control without too much interference on the performances. On the contrary, TeamViewer heavily affects the PC performances, so you cannot run significant connection sessions while using it for support.

Contact the project team at lola-project@garr.it for further information or details.

* * *

Appendix J – USB3 EXTENDERS

In order to use USB3-Vision cameras at a long distance (above the recommended 3 meters), you can use USB3-Vision active cables or optical fiber USB extenders. We have extensively and successfully tested the following products:

- 10, 15 and 20 meters USB 3.0 Active Cable by Ximea; they are provided with thumbscrews lock connectors;
- NEWNEX FireNex-5000 or 5000s, USB 3.0 Optical Fiber Repeater Extension System. This system is capable of repeating/extending USB 3.0 signal with 5Gbps SuperSpeed bandwidth for up to 300 meters.

NOTE: To correctly connect the Firenex-5000 extenders, please carefully read the instructions provided by Newnex.

Acknowledgments

We would like to thank:

- Ximea support and specially Max Larin for the useful suggestions and for collaborating with us;
- the GPUJPEG library authors for giving us the permission to use it inside LoLa;
- the LoLa users community for helping us in testing/debugging and suggesting new features!