

Magic Lantern

Canon EOS Camera Tool <u>www.magiclantern.fm</u>

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1.1 What is Magic Lantern?

- Free Open Source (GPL) firmware addon for Canon EOS cameras.
- Developed by hobbyists but used by professionals.
- Hardware very capable, but softwareside was never meant for advanced, professional film work.
- Magic Lantern adds advanced film (and photo) functionality.





1.2 DSLRs in Hollywood...

Examples for successful feature films that were mostly shot with DSLRs (Canon EOS 5D, 7D):

- Dimensions
- For Lovers Only
- Like Crazy
- Act of Valor





COD LOVER

FOR LOVERS ONLY

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2.1 Challenges of DSLR Video Work

- Video functionality quite limited compared to pro video and film cameras
- No autofocus (possible with 650D, but sadly quite unusable)
- Rolling shutter
- **Moiree** (line skipping)
- **Consumer codec** (h264, 8bit)
- Recording limit of max. 4GB/30 minutes
- Framerate >30 only possible in 720p
- No pro audio, no timecode (Exception: 5D3)
- Monitoring: No SDI, HDMI is only outputting at 480p when recording

2.2 Advantages of DSLR Cameras

- Price (Canon EOS 600D ~430 EUR)
- 1080p30 / 720p60
- Light, small, handy (600D 570g)
 - inconspicuous
 - rigs, steady, etc. affordable, too
- ISO/Sensor Size
 - crop / noise / low-light / DOF
- Picture Styles (=LUT)
- Lots of lenses and adaptors available
 - (Canon, Nikon, ...)
- Storage very affordable

2.3 DSLR Codec Challenges

- 8 bit (major loss of dynamic range)
 Difficult decisions
- Compression artifacts

 Motion heavy scenes can have problems
- Not an all-i codec
 - p frames need to be calculated (cpu heavy)
- Blacks lose detail
- Sharpness greatly reduced compared to foto functionality

3.1 Best Practices / Workarounds

Audio

- Turn off AGC (Automatic Gain Control)
- Don't use the internal preamp = +0db :)

Solutions:

- External PreAmp
 - (Juicedlink, Sound Devices 302, wireless = line level)
- Exernal Recorder (Zoom, Tascam), post-sync
- High output mic

Timecode / Sync

- Externer Recorder
- Pluraleyes

3.2 Best Practices / Workarounds

Video

Picture Styles (<u>http://philipbloom.net/2011/09/18/pictureprofiles/</u>)

like lookup-tables (converting 14bit->8bit pre-compression)

- Turn off sharpening in Camera (and do it in post)
- Focus: Digital Zoom 5x/10x
- Use a viewfinder
- Rig, Quick Release, ND Filters
- even if your NLE supports h264 natively (most of them do nowadays) you should convert to an all-i codec like prores or cineform

8bit >	denoise >	dither >	10 bit >	<pre>color grading ></pre>	film grain
	neat video	cnoise < 1%	trillions of colors		stock
	(sharpen)		prores hq		
	http://neatvideo.com/		http://rarevision.com/5dtorgb/		

4.1 Who would use Magic Lantern?

 Normal consumers -(point & shoot camera users)
 Home professionals ++
 Semi professionals ++
 Professionals +
 Tinkerers +++

(want control over the device they bought)

That said, we believe ML is suitable for professional use.

Quotes:

Reddit User: "You will see absolutely no need to uninstall it, nor will you want to, unless you're one of those folks that prefer to shoot in full auto all the time, in which case you'll find ML dreadfully unhelpful."

4.2 History and Community

- **2009-2010**: mostly one-man show (Trammell Hudson)
 - Inspired by CHDK (boot method), but new code
 - First camera: EOS 5D Mark II
 - First code on Bitbucket: April 2009
 - Community mainly collaborated on mailing list, wiki and Vimeo group
- Since **2010**: Alex is the main dev and coordinator
- Xmas 2011: HDR video
- 2012: new website: <u>www.magiclantern.fm</u>
 - Post on mailing list, suggested setting up community website, people got together: Forums, twitter, etc..
 - EOS 7D finally working

4.2 History and Community

• 2013:

- 14bit RAW Video
- Dual ISO
- Timecode Generator (very beta)
- New On Screen Display
- Profiles
- Auto ETTR (Exposure to the Right)
- New RAW file format
- Auto Exposure
- Advanced Scripting
- Module System
- Arkanoid :-)

4.3 Supported Models, Statistics

14 cameras ported or in progress*:

1100D*, 500D, 550D, 600D, 650D*, 700D, 1100D, 100D, EOS M*, 40D*, 50D, 60D, 6D*, 7D, 5DC*, 5D2, 5D3

Community:

300.000+ downloads and 27.000+ registered users

Source Code:

- 9,214 commits made by 86 contributors
- 280,441 lines of code mostly written in C

Ohloh: "This is one of the largest open-source teams in the world, and is in the top 2% of all project teams on Ohloh."



5.1 How our team works today

Core Team:

- People who put all pieces together
- People for some special topics
- People who take care of camera models

"All play together nicely, no dictation, no overruling."

New developers usually have a background in embedded hardware programing and have to find their way around ML on their own. The core team tries to help as much as possible.

Community support: Future challenges because of the success of the project (i. e. forum administration).

5.2 How our team works today

With every new discovery and feature, we can apply the new tricks to other areas of our software.

Example:

- One dev wrote a tool to detect memory areas that continuously change
- Another found a way to dump RAW Liveview data
- And yet another analyzed the RAW format

RAW histograms

- + DMA setup
- + CF optimizations
- + community feedback
- = RAW Video

6.1 Live Demonstration



6.2 Live Demonstration - Features

- Photo:
 - Advanced HDR bracketing, Very long exposures, Macro focus stacking, Trap focus, Motion detection, Dual ISO
- Video:
 - Audio: Live audio monitoring, Manual audio control, Internal/ external/mixed microphone modes, Balanced line input
 - Display: Advanced Infos, Cropmarks, Focus peaking, Magic zoom, Zebras, Histogram, False color, Waveform, Vectorscope
 - Recording: Bitrate controls, HDR Video, 14bit RAW Video
- Scripting:
 - Run your own programs on the camera (PicoC)
- Modules support:
 - Working comparable to Linux Kernel Modules
 - Adds functionality without touching "ML Core"

6.3 14 bpp RAW Video

- Recording 1920x1080 @ 24 fps
- ~85 MiB/s video stream
- Saving raw bayer pattern bitstream
- 14 bits per pixel
- Needs post-processing
- Astounding results
- 60 fps possible
- Getting more and more stable now

Quotes:

EOSHD:

"I have no other words to describe it – this is huge. news (...) The world just exploded." Cinema5D: "It's a revolutionary time for indie filmmakers" Neumann Films: "We are impressed, to say the least!"





source: Wikipedia

Standard H.264

Source: www.eoshd.com

RAW Video

1

Source: www.eoshd.com

3.81

1.00

7.1 Hardware Details

- Coprocessor
 - Toshiba TX19A (ROM/RAM 512/24 KiB)
 - Handles real-time tasks
 - Shutter, Mirror, Keys, AF, Metering, etc
- DiGiC 4/5:
 - Embedded ARM Core
 - ARM946E 200 MHz
 - 8 KiB I/D cache
 - No MMU, but MPU
 - Dedicated HW in ASIC
 - JPCORE, en/decode JPEG and H.264
 - KAISER, hash/checksums
 - EDMAC, fast DMA controller
 - ADKIZ, DEFM, TWOADD, ADMERG, SHAD, SPI, ...
- 256M / 512M RAM
- LCD, CF, SD, WiFi, GPS, ...



7.2 Firmware Details

- Boot process
- Firmware update
- Main Firmware
 - OS called DRYOS
 - Real time OS
 - Based on µITRON4.0
 - Priority based dynamic scheduling
 - Dynamic memory management
 - Middleware, Mailbox system



8.1 How does Magic Lantern work?

- Runs in RAM only
 - No need to flash anything
 - No warranty void (?)
- Hooks into original firmware startup
 - Shrinks memory pools
 - Hooks original firmware tasks
 - Techniques used for hooking
 - relocation into RAM + patching
 - cache hacks to "patch" flash data
- Starts own tasks
- Implements its own menu
 - Full control over visual appearance
 - More flexibility
- Accesses image buffers, hardware registers, and more

8.2 How is ML being executed?

Method 1: Firmware update

- We forge a firmware update file (.fir) with Magic Lantern as payload
 - Contains no flash data
 - Flash loaders in .fir are replaced with our code
 - Checksums and hashes need recalculation
- User runs firmware update from original firmware menu
- Firmware restarts into bootloader
- Bootloader loads .fir into RAM and executes it
- Magic Lantern takes over control of the system and boots original firmware

8.3 How is ML being executed?

Method 2: Autoboot

- Using .fir we set a flag in flash called "BOOTDISK"
- Bootloader checks for "AUTOEXEC.BIN" on CF/SD
- If found, it gets loaded and executed without checks
- Magic Lantern takes over control of the system and boots original firmware

#ifdef CONFIG 6D

// Hijack GUI Task Here - Now we're booting with cache hacks and have menu.
cache_fake(0xFF0DF6DC, BL_INSTR(0xFF0DF6DC, (uint32_t)hijack_6d_guitask), TYPE_ICACHE);
#endif

task_create("ml_init", 0x1e, 0x4000, my_big_init_task, 0);

9.1 Legal issues

These issues apply to all third-party software mods, and should be similar to smartphone jailbreaking. Cameras are *no* software ecosystems, though.

- Open question: is ML infringing on Canon's IP?
 - ... we hope not ...
 - Still in the process of figuring this out (with the help of EFF and SFLC)
- Copyright
 - We do not copy verbatim Canon code in Magic Lantern.
 - By relying on Canon code (called as an undocumented API), could Magic Lantern be considered a derivative work of Canon's firmware?
 - Common sense says no. Windows programs are not derivative works of Microsoft Windows. Same for smartphone apps.
 - GPL suggests the contrary: if you link to a GPL library, you must license your program as GPL.

9.2 Legal issues

• Reverse engineering

- Both US and EU laws allow reverse engineering for interoperability, without requiring the permission from the copyright holder (Canon).
- We examine Canon firmware by disassembling, decompiling and experimentation (trial and error).
- Do we need to use the Chinese wall technique?
- Encryption and Digital signatures
 - Canon updates are encrypted and signed => DMCA issues.
 - We do not publish crypto keys neither algorithms. Signing and encryption tool is kept internal to the team.
- "Ethical decisions"
 - If say we figured out how to shoot 4K video, would it be a bad idea to add it to every camera model out of respect for Canon?

10.1 Is Magic Lantern good for Canon?

<u>Pro:</u>

- Developers and users create and test new features for free, and publish the related code source. These features are not patented by ML If one feature is positively received, Canon may include it officially (video manual control, remove auto audio gain, clean HDMI out, raw video, ..)
- People that want to hack their DSLR will prefer a Canon one!
- ML team may find bugs in Canon firmware (already 3). We are OK to help fixing them.

<u>Con:</u>

- DryOS and Digic information is revealed. But competitors certainly could do the same...
- Some cameras could be broken and sent to Canon support partners for fixing during warranty period. (No reported case so far!)
- Features on lower price models may outperform higher priced ones (that are not supported by ML).

Samsung and Nikon already provide Android based cameras. Will Canon be the first manufacturer to provide DryOS and Digic devkit for hackers?

10.2 Legal issues

Related cases

- Sony vs Hotz (PS3)
- Sony vs Aibo hobbyists
- Texas Instruments vs TI-83 calculator hobbyists
- Creative vs Daniel Kawakami (sound card driver mods)
- Lexmark vs Static Control Components (printer cartridges)
- Chamberlain vs Skylink (garage door opener)

• Financial questions

- are donations making us vulnerable?
- is forming a NPO the only way to avoid e.g. taxes? (its not our income, we spend all money for cameras)

Further reading

- www.eff.org/issues/coders/reverse-engineering-faq
- <u>www.eff.org/wp/unintended-consequences-under-dmca</u>

11. Other similar projects

// we are not alone :)

- Canon: CHDK (consumer compact cameras)
- Panasonic: <u>www.personal-view.com</u>
- Nikon: www.nikonhacker.com
- Pentax: <u>www.pentax-hack.info</u>
- Sony: <u>www.nex-hack.com</u>
- GoPro: investigation in progress (CHDK)

Open source camera projects (Hardware)

Apertus, Elphel, LeanXcam, Stanford Camera 2.0

12. Future Outlook

It is very difficult to make any reasonable predictions (i.e. possibility of HDR or RAW video).

Steady growth of community (both users and developers) will present both new challenges and opportunities.

... just keep the project rolling!

Thanks!

You are welcome to join us for a hands-on demo after the talk.

Please visit:

www.magiclantern.fm



We are always looking for more developers and reverse engineers!

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Please login	or register.					
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Head	ine news The old chat died, join the "backup" here	1				
Magio	Lantern Releases					
	Stable Releases Official Stable Release Announcements	177 Posts 1 Topics	Last post by RenatoPhoto in Magic Lantern v2.3 on Today at 12:57:55 AM			
	Release Candidate (RC) announcements Testing before stable releases. Bug fixes only. No feature requests please.	407 Posts 6 Topics	Last post by jakdaniel1975 in Third alpha for 5D Mark on May 19, 2013, 02:44:19 PM			
	Nightly Builds Stay up to date with the lastest and greatest development. For testers only. They may work or they may not. Use at your own risk.	438 Posts 5 Topics	Last post by ds/rookie in Nightly Builds - try the on Today at 03:18:46 PM			
Show	casing Magic Lantern					
	Share Your Videos Show off your Magic Lantern created films!	1344 Posts 399 Topics	Last post by 1% in 5D mkll RAW low light t on Torday at 07-17-35 PM			
	Nearest Text Share Your Photos Show off your Magic Lantern created photos!	439 Posts 109 Topics	Last post by N/A in One More Time With Feel on Today at 01:31:57 PM			
Using	Manic Lantern					
	General Help Q&A Have a question about Magic Lantern? Confused by a feature? Here's the place to ask.	6525 Posts 1291 Topics	Last post by Aquilium in SSOD StentPic DNG + Int on Today at 07:11:25 PM			
	Child Boards: Camera Emergency Department Hardware and Accessories	724 Posts	Last post by xaled			
	Lenses, Mics, Field Monitors, and More	99 Topics	in camranger IOS remote con on Today at 01:36:29 PM Last post by allex			
	Share your tips and techniques for getting the most out of Magic Lantern's many features.	53 Topics	in How to record: - RAW DL on Today at 12:46:20 AM			
	How to prepare your camera for a shoot. What specific settings are used at weddings, wildlife filming etc. Specific use of picture styles.	274 Posts 39 Topics	Last post by noisyboy in Raw video - preparation on Yesterday at 11:28:24 PM			
	Post-processing Workflow Share your workflow and discover new ways to process your Magic Lantern created photos and videos.	700 Posts 53 Topics	Last post by Murphy in After Effects HDR Video on Today at 02:11:38 PM			
	Script Writing Control your camera with PicoC scripts. No compiler needed, just write your own code in Notepad. Share your scripts here.	137 Posts 14 Topics	Last post by a1 ex in PicoC scripting API on Today at 02:24:28 PM			
Deve	oping Magic Lantern					
	General Development Discussion Need help compiling? Want to help with debugging and testing? Come here to stay up to date on current development efforts.	6893 Posts 270 Topics	Last post by 1% in 12-bit (and 10-bit) RAW on Today at 07:18:56 PM			
	Bug Reports Anything not working as expected? Report issues here. Child Beards: Closed Bugs	2268 Posts 452 Topics	Last post by cratypig in [WONTFIX] Many dead pixe on Today at 06:48:48 PM			
	Feature Requests Share new features that you would like to see in the next Magic Lantern release. Please search first to avoid duplicates.	3910 Posts 651 Topics	Last post by 1% in New FRAME HEIGHT for 60 on Today at 06:56:49 PM			
	New ports Early ML ports - not yet fully supported Hederators Made, Luca, W	7625 Posts 33 Topics	Last post by noisyboy in Magic Lantern for 6D D on Today at 07:19:15 PM			
	Change Log View detailed updates to Magic Lantern and download source code on Bitbucket	14565 Redirects				
Proje	ts		Last next by fy			
	Video Lutonals First community project to produce video tutorials for basic features in ML v2.3	25 Posts 5 Topics	in Help with "freezing" in on April 26, 2013, 06:18:49 PM			
Gene	ral Discussion General Chat					
	Chat about new camera models ("when is the 1D2mkil port coming???), DSLR filmmaking accessories; your favorite (or least favorite) picture styles, tricks of the trade, and any other related topic.	1358 Posts 188 Topics	in The Magic Lantern Storm on Today at 03:51:14 PM			
	User Introduction Let us know who you are	316 Posts 158 Topics	Last post by Rill in Hi there Tom here on Today at 03:11:14 PM			
	Magic Lantern Forum and Site Discussion Have a particular facture yood like to see a tutorial on or an idea for a new board? Share with us your suggestions to make this ste better.	248 Posts 64 Topics	Last post by Marcurion in ML working on 50 Mark II on Today at 01:59:46 PM			
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