CINEMA ROBOTS

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Abstract: *This paper will investigate a brief history of cinema robots and examine the potential of robotic arms like KIRA and Bolt for cinematography.*

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1 Introduction

With the constant breakthroughs in technology each field of industry or entertainment is not the same as it used to be 30 years ago. The invention of integrated circuits and microchips revolutionized everything and since 1970's humanity strives to minimize the size of electronics. Production methods and the quality of microchips are getting better and cheaper every year. Given these advancements it is easier than ever for small companies to start experimenting with industrial robots and robotic arms. The precision and repeatability offered by these instruments cannot be surpassed by any human. It was just a matter of time before someone used robots in film industry.

2 Brief history

Despite the film being described as moving pictures the earliest films had very little moving camera shots as possible. It was thought that moving the camera could confuse the viewer. Furthermore, moving the camera to follow the action would require more extensive planning of the shots and higher budget since the movement required its own technology.

First camera dollies and cranes were used in early 1920s, the Steadicam became popular in the 1960s due to high-end film cameras becoming more mobile.[16] First predecessor of modern robot camera systems was "cam machine" constructed by John Whitney Sr.[1] Cam machine was constructed from WWII analog computer mechanisms and Whitney used it to pioneer the concept of motion control in film. The device was essentially a robotic arm that could hold a camera and move it in various directions to capture unique and dynamic shots. Whitney used this device in his own experimental films and rented it out to other filmmakers who wanted to use it for their projects.[10]

In 1991 a new cinema robot was constructed by Mark Roberts. The robot was called Milo — a mechanized crane that allowed for free control of the camera in three dimensions and was capable of precise reproduction of particular commands including change in focus distance. Modernized version of Milo is still being produced today. Its maximum height is 4.12 m, maximum track speed can reach 2 $\mathrm{m\,s^{-1}}$ and rotate speed 30 $^\circ\,\mathrm{s^{-1}}$. Whole Milo rig weights 545 kg and 3 m of its precision tracks weight 90 kg.[2] It offers manual programming as well as programming of trajectory.[3] The team behind Milo won an Academy Award for Scientific & Engineering achievement in 1999.[14]

Next major innovation in the cinema robots was in the invention of the "Russian arm". The official name is "Autorobot". It consists of a gyro-stabilized arm mounted on a car and is used to capture dynamic camera shots from moving vehicles. The stabilized head made it possible to isolate the crane from all kinds of shocks, vibrations, and wind.[1] The operation of the arm was similar to Milo's however its biggest advantage was the freedom which the car provided. The original creator's name is Anatoliy Kokush and he was awarded two Academy Awards in 2005 in the Scientific & Engineering Award category for the concept and development of the Russian Arm, gyro-stabilized camera crane and the Flight Head.[4]

[1] John Whitney Sr. was an American animator, composer and inventor, widely considered to be one of the fathers of computer animation.

Figure 1: Modern version of cinema robot Milo [2]

3 Bolt is born

In 2012 Mark Roberts Motion Control (MRMC) produced the world's fastest highspeed camera robot called Bolt. It allowed to capture images in crisp focus that would be impossible to capture by hand or any other method. Bolt is 6 axis robotic arm and captures the quickest action with perfect accuracy as it transitions from a complete stop to full high-speed motion and back. The robotic arm can rotate 180 $^\circ\,\mathrm{s}^{-1}$ and move up to 2 $\mathrm{m\,s}^{-1}$ in both the horizontal and vertical directions. Bolt can hold up to 20 kg camera payload and track speeds up to 5 $\mathrm{m\,s}^{-1}$. Its standout features include high portability, lens control, target tracking, repeatability and ability to create time lapse with dynamic movement.[6] Bolt was used for filming Marvel films such as the Avengers and Ant-Man, Kendrick Lamar's "Humble" music video or car crash scenes in the Fast & Furious franchise.[15]

Figure 2: Cinema robot Bolt [6]

3.1 Bolt Jr

MRMC continued to develop cinema robots and the next generation robot was 9-axis robotics system Studiobot in 2014. After Studiobot MRMC introduced in 2018 the successor to Bolt called Bolt Jr. It was more compact, lightweight, and great for small studio spaces. In 2020 MRMC released updated version Bolt Jr+. Bolt Jr+ boasts a reach of 1.4 m, 10 kg payload capacity, portable build and is half the weight of the original Bolt model. Track speeds reaches up to 8 $\mathrm{m\,s^{-1}}$.[7]

3.2 Bolt X

The biggest member of the Bolt family is Bolt X introduced in 2019. Bolt X's horizontal arm reach extends 3.2 m from the rotate center and has a vertical travel of nearly 5 m, starting from its lowest position to the maximum height of 4.3 m. Track speed reaches 4.2 $\mathrm{m\,s^{-1}}$ and rotation speed is 180 $^\circ\,\mathrm{s^{-1}}$. Weight of the robot is 560 kg and its pedestal weights additional 372 kg. Its size and weight make this robot perfect for shooting music videoclips, commercials, product videos and films.[8]

3.3 Flair

All the MRMC products can be programmed using their own proprietary software called Flair. In Flair camera technician can adjust and set plethora of options and fine tune all the robot movements. It offers 3D view of the scene and by positioning the model in certain ways the whole movement can be recorded. Flair offers a frame by frame positioning of the robot which allows for very precise movement and can be used for stop and motion animation or repeatable complex paths. Using focus assist the user can always adjust the camera focus as needed. Small hardware addon can be attached to the front of camera to send information about targets distance for fine tuning the focus, iris and zoom of the camera. Using input trigger pulse signals allows the user to automatically start at the exact moment without any guesswork. Flair can import and export the path of the camera so the moves can be explored in other software packages for further editing. User can see the live view directly from the camera next to the model of the robot which updates in real time. It works on desktops, laptops and even tablets to further expand the customizability of the robot.[9]

Figure 3: Motion control software Flair [9]

4 Motorized Precision

4.1 KIRA

Motorized Precision (MP) is a new player in the field of camera robots. Partnered with prestigious camera company RED Motorized Precision introduced their first robot KIRA in 2016. KIRA is high speed 6-axis cinema robot that can be controlled by MP Studio motion control software. It can move the camera horizontally or vertically at 4.5 $\mathrm{m\,s^{-1}}$ and maximum track speed is 9 $\mathrm{m\,s^{-1}}$. Maximum height is 2.9 m, base pan is $\pm$ 185 $^\circ$ and it can travel up to 200 $^\circ\,\mathrm{s^{-1}}$. KIRA robot weights 260 kg, and entire robot with base and power wheels weights

839 kg. Maximum camera payload is 16 kg. Another way to control KIRA is by an Xbox Elite controller. MP engineers programmed their robots to be compatible with Xbox controllers to allow for intuitive control of the robot. Using controller users can pan, tilt, roll or move the camera up and down.[12]

Figure 4: MP robot KIRA [12]

4.2 MIA

MIA is MP's portable cinema robot option. It is much lighter than KIRA and smaller overall. It is the perfect solution for smaller spaces and for traveling since the whole robot with equipment can fit inside any van or sprinter. MIA has the maximum height of 2.46 m, it can move up to 3.2 $\mathrm{m\,s^{-1}}$ and maximum track speed is 7.7 $\mathrm{m\,s^{-1}}$. MIA's pan is $\pm$ 170 °, and it can move 300 $^\circ\,\mathrm{s^{-1}}$. Weight of the robot is 56 kg, weight of the mobile base is 367 kg and it supports up to 10 kg of camera payload. It can be controlled by MP Studio or Xbox controller.[13]

4.3 COLOSSUS

The largest MP cinema robot is COLOSSUS. Thanks to the enormous length of the arm its main benefit is enabling the user to get from macro to super wide in a single shot. Maximum height of the robot is 4.27 m, maximum speed of horizontal and vertical move is 6.8 $\mathrm{m\,s^{-1}}$ and max speed with track is 11.3 $\mathrm{m\,s^{-1}}$. Base pan is $\pm$ 185 ° and it can travel 180 $^\circ\,\mathrm{s^{-1}}$. COLOSSUS weights 549 kg, mobile base weights in travel mode 1061 kg and 2513 kg in shooting mode. Maximum camera payload is 23.6 kg. Just like the other MP robots COLOSSUS is also controlled by MP Studio or Xbox controller.[11]

4.4 MP Studio

MP Studio is the software developed by MP for precise control of their robots. Just as MRMC's Flair it offers useful features such as live monitoring for real time control, move presets creation and export, detailed control of the cameras focus, iris and zoom or time lapse feature to allow the user to program the robot frame by frame and many more.

Special version of the software called MP AR allows iOS users to place 3D model of a robot in augmented reality (AR) and fine tune all the moves using camera to see the moves in real life. Recorded moves can be exported back into MP Studio for further editing. The app can create AR sets with a virtual representation of the robot and set pieces. Test camera moves, reach, and if the robot will fit on location. Place keyframes or add camera shake while moving the iOS device. Previsualize entire scenes remotely for stunts, VFX, or commercial work. Users can use QR codes on objects to target precise points.[5]

5 Conclusion

In conclusion, the use of cinema robots like KIRA offers new possibilities for filmmakers to capture dynamic shots and create complex camera movements. The entire purpose of using these robots is that they move quickly, precisely, and with great strength. Although there are benefits to using cinema robots, there are also drawbacks, such as the need for skilled operators and high equipment and maintenance costs. On the other hand, their potential for precision and creativity makes them an exciting tools for the future of film making. Further research and exploration into the use of cinema robots in film production is needed to fully understand their potential and limitations. Basic specifications of the robots mentioned above are summarized in Table 1.

Table 1: Comparison of MRMC and MP robots

Specification	Bolt	Bolt Jr+	Bolt X	KIRA	MIA	COLOSSUS
Maximum height [m]	3.50	2.50	4.30	2.90	2.46	4.27
Lowest position [m]	0	0	-1.30	-0.71	0.47	-1.47
Maximum reach [m]	2.00	1.40	3.20	2.01	1.10	3.10
Horizontal move [$\mathrm{m\,s^{-1}}$]	2.0	5.0	9.7	4.5	3.2	6.8
Vertical move [$\mathrm{m\,s^{-1}}$]	2.0	5.0	9.6	4.5	3.2	6.8
Max speed with track [$\mathrm{m\,s^{-1}}$]	5.0	8.0	4.2	9.0	7.7	11.3
Weight (robot+base) [kg]	600	318	932	839	367	2513
Maximum camera payload [kg]	20.0	10.0	20.0	16.0	10.0	23.6

References

[1] Дмитро ДЕСЯТЕРИК. Ефект Кокуша, Розмова з творцем унікального кінообладнання, яким знімає весь світ. https://web.archive.org/web/20070310202841/http://www.day.kiev.ua/160578/, 2006. Accessed: 03.03.2023.

[2] Camera Control. Milo specifications. https://cameracontrol.com/milo-specs/, 2017. Accessed: 03.03.2023.

[3] Digital Cinema UA. Milo motion control: motion beyond reality. https://film.ua/uploads/document/2014/04/03/DCU_MILO_motion_control_en.pdf, 2014. Accessed: 03.03.2023.

[4] IMDb.com. Academy awards. https://www.imdb.com/event/ev0000003/2006/1, 2006. Accessed: 03.03.2023.

[5] Maher, M. You Can Now Control A Robotic Camera Arm With An iPad. https://www.premiumbeat.com/blog/use-ipad-control-camera-robot/, 2022. Accessed: 05.03.2023.

[6] Mark Roberts Motion Control. Bolt high speed camera robot. https://www.mrmoco.com/motion-control/bolt/, 2022. Accessed: 03.03.2023.

[7] Mark Roberts Motion Control. Bolt Jr+ compact high-speed rig with extended reach. https://www.mrmoco.com/motion-control/bolt-jr-plus/, 2022. Accessed: 03.03.2023.

[8] Mark Roberts Motion Control. Bolt X longest arm reach. https://www.mrmoco.com/motion-control/bolt-x/, 2022. Accessed: 03.03.2023.

[9] Mark Roberts Motion Control. Flair. https://www.mrmoco.com/motion-control/flair/, 2022. Accessed: 03.03.2023.

[10] Moritz, W. Digital harmony: The life of john whitney, computer animation pioneer. https://www.awn.com/mag/issue2.5/2.5pages/2.5moritzwhitney.html, 1997. Accessed: 03.03.2023.

[11] Motorized Precision. COLOSSUS. https://www.motorizedprecision.com/colossus, 2023. Accessed: 04.03.2023.

[12] Motorized Precision. KIRA. https://www.motorizedprecision.com/kira, 2023. Accessed: 04.03.2023.

[13] Motorized Precision. MIA. https://www.motorizedprecision.com/mia, 2023. Accessed: 04.03.2023.

[14] MRMC. Our company history. https://www.mrmoco.com/about-us/history/, 2021. Accessed: 03.03.2023.

[15] RW2 Productions. Bolt Motion Control Cinema Robot Finds Home in KCMO. https://www.rw2productions.com/bolt-motion-control-camera-kansas-city-mo, 2021. Accessed: 03.03.2023.

[16] Winokur, M., and Holsinger, B. *The Complete Idiot's Guide to Movies, Flicks, and Films*. alpha books, 2001.