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Implementation of a low-cost Cable Cam System

Summary

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Executive summary

This thesis classifies and describes professional cable cam systems already available on the market and introduces a self-developed low-cost system for no-budget and low-budget film productions (limit of expenses 1,000 euros). All components of the system and the process of development until the first deployment are described in detail.

The resulting system was designed for the Panasonic AG-HPX171 Camcorder[1] and consists of a cage powered by a rechargeable battery with remote-controlled pan tilt head. It is driven on a horizontal tensioned bearer cable by its own engine.

Figure 1: Panasonic AG-HPX171

Requirements concerning the construction of a pan tilt head:

- Continuous pan operation and smooth, stepless speed control
- Continuous tilt operation and smooth, stepless speed control
- Firm and bounce-free construction without slackness
- The power transmission for the tilt motor works via distributing jumper ring.

The Item Industrietechnik GmbH[2] company offers a system module for building machinery and operational supplements that is ideal for the realisation of the intended project. The pan tilt head was constructed from various “Al profiles” from model line 5. The Item company prefabricated the profiles (sawing, drilling, thread cutting etc.) and delivered the parts as a finished construction kit.

For navigation and controlling, the cable cam system possesses a simple radio transmission system that sends the video data from the camera onto a small screen. For this purpose, an AV radio transmission system in the 2.4 GHz band[3] is used which has a declared range of 80 meters.

The cage actuator and both engines of the pan tilt head are controlled by a simple consumer radio remote control. The sender works with transmission safe FM modulation

[1] http://www.panasonic-broadcast.de/de/produkte/p2-series/p2-cam/AG-HPX171.php (11.11.2009)
[2] http://www.item.info
[3] Item-no. 351238 at http://www.conrad.de

(PPM) at 40 MHz and has four proportional control channels with separate trimming and reverse function[4].

The channels are allocated as follows:

1) pan motor control (rotation)
2) tilt motor control (pitching)
3) cage drive (movement)
4) no function yet

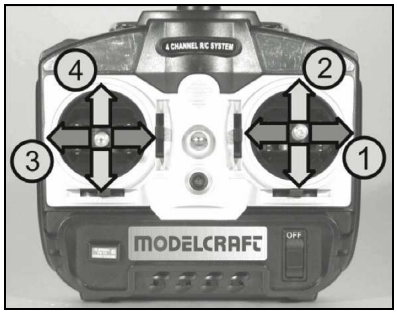

Figure 2: Channel configuration

For pitching, a cheap 12 V DC gear motor made by Modelcraft[5] with a transmission ratio of 1:600 is used which can reach a speed of nine revolutions per minute under load. This is equivalent to a maximum angular speed of 54 degrees per second. The maximum load current is specified as 2.1 A.

The tilt engine rotates the pan-fork via two gearwheels (with 20 and 100 cogs, respectively), so that five engine rotations are needed for a full pan-fork rotation. Again, the 12 V DC gear motor[6] made by Modelcraft is used, but this time with a transmission ratio of 1:200. 26 engine rotations per minute under load result in 5.2 pan-fork rotations per minute, i.e. 31.2 degrees per second.

An MFA/COMO DRILLS[7] 12 V gear motor with a transmission ratio of 11:1 was chosen as the driving motor. At 12 V, it provides an idle-running speed of 1,436 rotations per minute. The cable pulley has a diameter of 38 mm. Therefore, the resulting theoretical maximum speed is:

$v_{max} = d \bullet \pi \bullet \omega = 0.000038 \text{ km} \bullet \pi \bullet 1{,}436 \bullet 60 \text{ rev/h} =$ <u>10.3 km/h</u>, or <u>2.86 m/s</u>

Because the engine is always working under load, the actual speed is expected to be much lower.

For the electrical power supply of the cage (three 12 V engines and the receiver), a maintenance-free 12 V lead-acid battery[8] made by Panasonic with a capacity of 4.5 Ah

[4] Conrad: „Operating Instructions of the Modelcraft 4-Channel Remote Control Sets 40 MHz“
[5] Item-no. 221936 at http://www.conrad.de
[6] Item-no. 227579 at http://www.conrad.de
[7] Item-no. 222363 at http://www.conrad.de
[8] Item-no. 250775 at http://www.conrad.de

was chosen. Because the receiver of the radio control only works with 5 V, it is supplied indirectly with power by the BEC circuit of one of the three cruise controls[9].

A steel wire rope with a length of 60 m and a diameter of 6.1 mm is used as bearer cable. It can be tensioned between two anchor points with the help of a grip-hoist by Planeta. The grip-hoist is approved for a weight of up to 500 kg but is only used with a load of at most 400 kg for safety reasons. For the same reasons, there is a limit for the slack of the rope (D) which must be ensured, and which can be estimated by the following equation:

$$D = (A / 2) \cdot (G + A \cdot s) / (2 \cdot S)$$

A: Distance between anchor points

G: Weight of the cage (approximately 12.5 kg)

s: rope weight per meter (approximately 0.13 kg/m)

S: Maximum permitted rope weight (400 kg given as a limit, giving a reserve of 100 kg)

Worked sample:

How much is the slack of the rope for an anchor point distance of 50 m?

$$D = (50 \text{ m} / 2) \cdot (12.5 \text{ kg} + 50 \text{ m} \cdot 0.13 \text{ kg/m}) / (2 \cdot 400 \text{ kg}) = \underline{0.594 \text{ m}}$$

The slack of the rope for an anchor point distance of 50 m is approximately 60 cm.

Besides the grip-hoist, various other tools are necessary, such as small ropes for fixation, nooses, and shackles. These tools can be used to attach the bearer cable to trees, cross-bars, or beams.

During the implementation of the project, no serious difficulties were encountered. All applied components worked together well. The finished cage with pan tilt head and radio transmission system has a weight of nearly 10 kg. Together with the camera, the system has a total weight of 12.5 kg.

[9] Item-no. 228300 at http://www.conrad.de

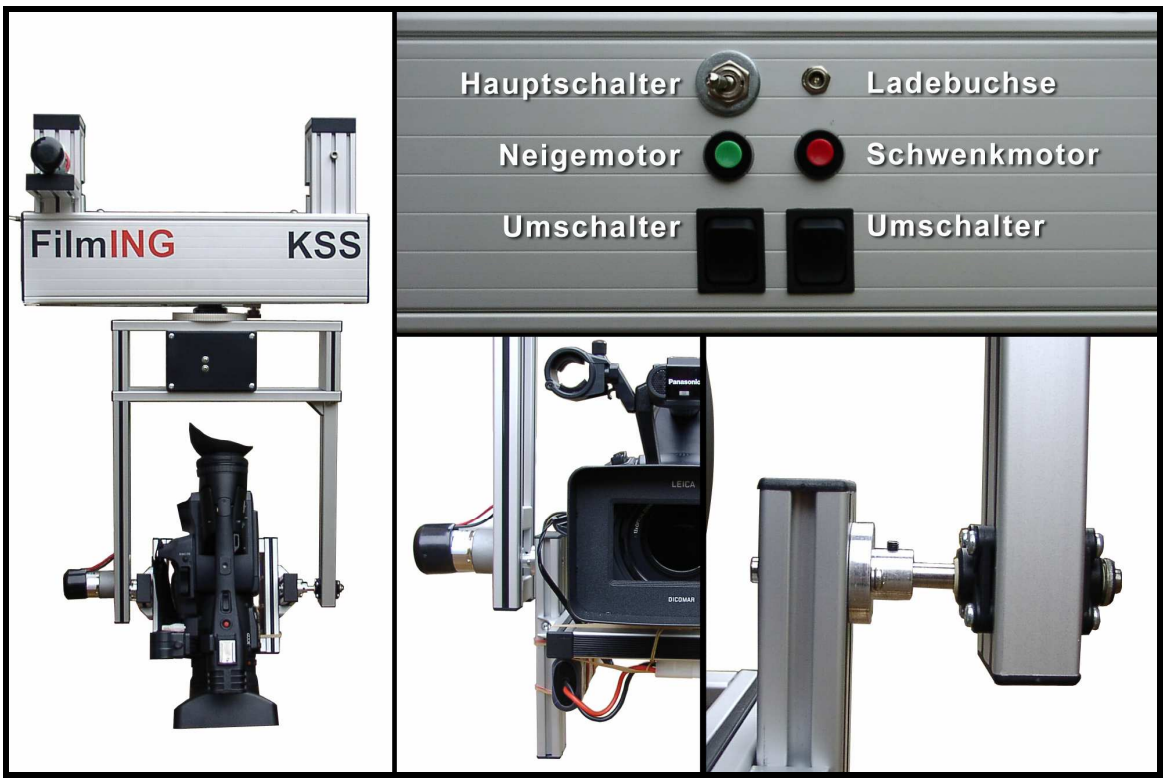

Figure 3: The ”FilmING” Cable Cam System
Left: Overall view of the cage; Top: Functions of switches and pushbuttons; Centre: Axis with tilt engine; Right: Tilt axis with bearing.

The whole system could be realised for a capital investment of just under 1,500 Euro and works well in practice. The installation requires two persons and lasts about one hour; the de-installation takes only about half an hour. First tests took place in the rope course Hamburg, where trees were used as anchor points and the active length of the bearer cable was about 30 m, and in the “Gängeviertel” of Hamburg during a Turbo Kino Kabaret, with anchor points on the cross-bars of windows and an active length of the bearer cable of 40 m. The system worked well but also showed room for improvement.

The following weaknesses could be noticed during the work with the cable-cam-system:

1) It causes serious problems that the drive works only on one cable pulley. The reason is a high motor torque and the low friction between pulley and rope, so that sometimes the pulley loses grip and the whole system starts wobbling and swinging. Closer examination showed that this problem depends on the direction of movement, probably due to the different gradients of the cable pulleys.

Figure 4: Cable pulley and gradient

The solution for this problem could be a chain drive that drives both cable pulleys equally.

2) A second weakness is the fixation of the tilt axis. The two little allen head screws are difficult to reach, but if those screws are not firmly tightened, some slackness occurs due to the flattening of the tilt motor axis, which leads to wobbling of the camera. A new, bigger bearing could help. It might be possible to use a bearing from a bycicle handlebar, which would have the additional advantage of additional cable bushing for further camera control cables.

3) The lack of ability to control the camera is a further problem, but again there is a solution. Panasonic supplied me with the technical manuals for both remote control connections. The electronic components for the realisation of the circuit are cheap, but a new radio remote control with further channels would be needed.

4) Due to the single rope principle, the system tends to swing, wobble, and bounce. A new chain-driven cage would be more stable. Furthermore, consideration should be given to the implementation of a construction with two bearer ropes, which would have the advantage of a better division of the affecting forces. Another possibility would be the use of an active or passive gyro stabilisation.

5) The greatest problem is that for professional use of the cable-cam system, a national certification according to safety rules is mandatory (BGV C1[10]: „Unfallverhütungsvorschrift: Veranstaltungs- und Produktionsstätten für szenische Darstellung“ and BGI 810-3[11]: „Sicherheit bei Produktionen und Veranstaltungen – Lasten über Personen“). Such a certification results in additional costs of about 5,000 euros. In addition, the cable-cam system was not designed for such high safety requirements (for example, an overdimensioned

[10] VBG, BGV C1
[11] VBG, BGI 810-3

capacity for all bearing parts in order to provide a safety margin) [12], so parts of it would have to be redesigned.

In conclusion, the aim to construct and build a working cable-cam system for not more than 1,000 euros could not be attained completely. The result was a good, working system despite a few problems that easy to solve for a very low price. However, even without the image transmission system, the stated cost limit was exceeded by approximately one third, and the costs for the safety certification were not considered in the calculation.

Nevertheless, the work on this project was not in vain and the experiences gained help to better understand where the difficulties lie in constructing a professional system as well as how much such a system would cost. A real professional working system with a pan tilt head camera that has a gyro stabilisation and full access to all camera options would require an investment of about ten times the price scheduled for this project.
On the other hand, this thesis shows that even with little effort, it is possible to achieve surprisingly good results, which is of particular significance for no-budget and low-budget projects.

[12] VBG, BGI 810-1 and VBG, BGI 810-3

Appendix

List of figures

List of literature

Conrad: „Operating Instructions of the Modelcraft 4-Channel Remote Control Set 40MHz", 2006, Item-no. 23 31 73, Conrad Electronic SE, Conrad-Onlineshop at http://www.conrad.de (06.11.2009)

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