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Domain Model of Low-Budget First Generation Stereoscopic 3D TV Production

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Introduction

The interest in 3D is constantly growing thanks to recent cinema involving in 3D movies, both at user side and content producers one. Bring 3D at home is seen as a possible great market. Nowadays stereoscopic displays and Blu-ray 3D players are next to hit the market and give a first sample of 3D home perception.

The fundamental principle underlying 3D TV conversion techniques rests on the fact that stereoscopic viewing involves binocular processing by the human visual system of two slightly dissimilar images [1, 2].

There are considered to be at least three, possibly five generations of 3D TV which will progressively come into play in the years ahead [3]. The 3D TV we speak of today is usually First Generation – stereoscopic television based on two camera images, which are shot, edited, encoded and delivered to the viewer, who will have some arrangement (usually special glasses) to ensure that the left and right eye signals get to the corresponding eye.

The main commercial requirement for the today 3D TV specification is that broadcasters can use an existing DVB HDTV broadcast channel, and viewers can use an existing or suitably adapted receiver to receive the 3D TV content [4].

Searching a solution, low-budget program makers quickly discover that there is no existing model within the 3D broadcast and production industry to which they can turn. Today's "off-the-shelf" expensive 3D digital production solutions rarely do everything needed by the typical local or regional media enterprise – simplified and inexpensive 3D production. Ultimately, what is needed is a complete re-thinking of the way technology can be applied to the art and business of 3D program making and low-budget broadcasters should reconsider alternatives of partial in-house developments.

Software-intensive 3D TV production system can be considered as a multimedia information system and development practice applicable for that type of information systems should be applied. Also, positive experiences from previous software-intensive television systems should be used in synthesis of system for stereoscopic production [5–7].

Primary aim of this paper is to propose one model-driven approach of software-intensive 3D TV production system applicable and suitable for low-budget broadcasters. The target of the project is to figure out one of possible future scenarios for implementing stereoscopic 3D technologies in low-budget TV production and to propose one domain model suitable for further expansion.

The first step of the project is to describe the whole 3D TV content production chain. The second step is to propose one 3D TV production workflow and to define the conceptual model in problem space which is suitable for low-budget 3D TV production.

The three distinct yet related modelling spaces are defined: problem, solution and background. These modelling spaces have been formally considered and discussed by Unhelkar in [8]. Modelling of problem space (MOPS) is used as a research method in this paper. The modelling output transcends both data and code and results in a suite of visual models or UML 2.0 diagrams. The use cases contain the behavioural (or functional) description of the system. Class diagram provide the structure of the domain model.

Stereoscopic 3D TV content production workflow

The professional video production process usually requires three distinct phases: preproduction, production and postproduction [9]. A production workflow can be considered in a number of stages. A producer works within a framework for a specific program which is called a format [10].

Low-budget broadcasters recently faced with significant financial exhausting during the process of transition from analogue to digital production and large investment in new system is not an option in this moment.

Basic production stages defined here are: development, planning, acquisition, processing, control, archiving and publication. These stages and production processes are shown in Fig. 1.

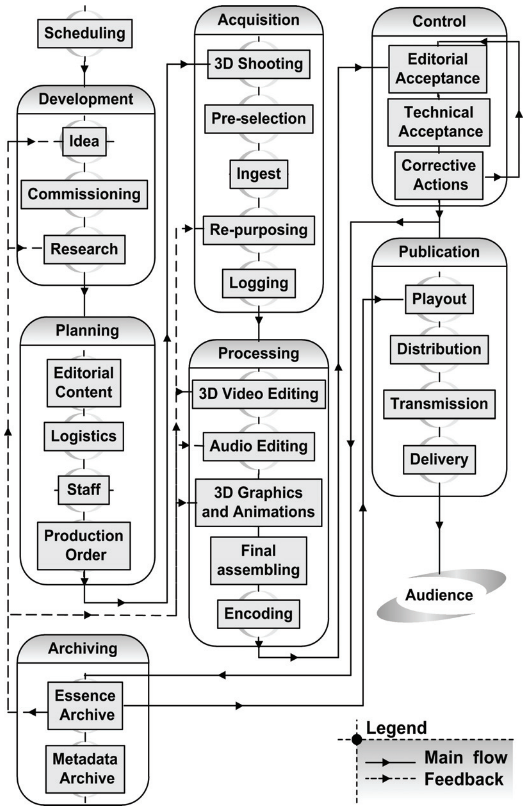

Fig. 1. 3D program production workflow

Development. A program's life traditionally begins with a need to fill a slot in a schedule. New skeleton schedule is produced from the analyses of the audience numbers and reactions. This schedule has to encompass details of the program categories, possibilities for re-using (repeat) of the programs as well as outline budgets of the programs required to fit into slots.

New generation of directors and editors, as well as screenwriters and producers who understand 3D and create their stories with depth is needed. That means that producers should be aware of visual constraints that stereoscopy imposes on 3D production tools.

The 3D effect has to be modulated throughout the story, and that modulation has to be scripted. A depth script (stereopsis) is just the description of the amount of depth throughout time.

During the development stage, program ideas are investigated and a commission results when the producer persuades the TV company to finance the conversion of an idea into a real program. When a commission has been accepted research was done and archives and other databases are examined for potential contributors, locations, facilities and material that can be re-used.

Planning. The planning encompasses the staffing, resources and also the creation of the artistic description in the form of a storyboard and script.

Before going into 3D production, answers on important organisational and technical questions should be found (how 3D affects all phases of production, the new 3D storytelling constraints and related tools, the stereopsis process and the depth script should be defined etc.) [11].

On the end of the planning stage a production order may be produced.

Acquisition. During the acquisition stage, 3D video shoots, audio clips and other program items are created, ingested into production system and logged.

The majority of 3D broadcast material available today has been produced using a twin-lens or dual-camera configuration giving a stereo pair where the left-eye and the right-eye views are separately recorded from slightly different perspectives. A fundamental way to capture a stereoscopic TV signal is to use two cameras mounted on the same axis and separated by the spacing of the average pair of human eyes (6.25cm). Camera spacing can be varied, and cameras can be 'toed in', to achieve different elements of picture composition. Filming parameters such as camera base distance (distance between the two cameras), convergence distance (distance from the cameras to the point where both optical axis intersect), and camera lens focal length can be used to scale the horizontal disparity and thus the degree of perceived depth.

Stereoscopic capturing requires that both director and camera operator are highly skilled regarding stereoscopic geometry and camera calibration. Furthermore, the possibilities of adjusting the image pairs in postproduction are limited and time consuming.

At all points in capture there is an opportunity for metadata collection. Increasingly, devices that capture pictures or sound can automatically record much of the technical metadata from their own control systems. Those technical metadata can be very important during the postproduction phase, especially if dual camera adjustment and settings was not perfect and some minor imperfections and 3D image impairment can be corrected.

Ingest is the first stage to efficiently transfer captured 3D content to the television production infrastructure. During the ingest we take all 3D content (both view) collected during a shoot, as well as new metadata, and transfer it into the production environment. We assume that the planning and commissioning metadata are already in the system. More metadata can be generated at ingest and this can either be directly entered, or it can be extracted automatically.

Ingestion can be considered in terms of two processes, or fundamental tasks [12]:

- Content acquisition and optimization;
- Content description and referencing.

Content acquisition and optimization assume capturing the 3D audio-video essence and content compression. Ingest system should provide automatic generation of high and low resolution content representations. Standardization of master format for 3D Home production is on-going and details related to the quality of 3D video and audio as well as technical metadata important for ingest process will be suggested. During the content optimization the key frames should be extracted and recorded.

Logging is where the producers review what they have, and mark down its possible use.

Processing. Processing stage represents a craftsman work where the 3D shoots, clips, sounds and already assembled items are put into an order.

All processed material should be regularly checked in 3D. The images that read like 2D images should be edited like 2D. The images that have a strong 3D character need to be dealt with as 3D.

There are a variety of ways to edit a stereo project. Whole editing process, which is usually consisting of video and audio editing, has to be concentrated on capturing the composition metadata, so called Edit Decision List (EDL), in order to accurately represent the artistic composition of the program from its constituents. Typically, this results in two Edit Decision Lists, one for each eye. The source material might be organised with parallel directory and naming structures, so that a single EDL can be applied twice to generate the left and the right track.

Advanced effects and transitions like fades, wipes or cross-screens should be used very carefully, because they have a different behaviour in depth. Some of the editing tools offer creating of Depth Decision List (DDL), with information related to depth editing.

High-end editing systems are far too expensive to be used by the low-budget broadcaster who wants to take time to learn and experiment on his own. This is the reason why the low-budget broadcasters should choose the existing solutions to edit 3D using regular 2D tools.

Stereo sound was present in multimedia production long before 3D pictures. The new 3D sound-image space relationship has not yet been explored and discussed in open forums and conferences.

Different graphics, subtitling as well as animations are part of produced 3D content. Subtitles on a single screen plane of a stereoscopic content are not visually pleasing to the audience. What seems to work best is to position the subtitles slightly in front of the 3D point of interest in any given scene. This allows the audience to easily read the subtitles without refocusing.

Control. Editorial and technical acceptances, which are the constituent parts of the recurrent control stage, approve the use of the produced program material.

Technical control assumes quality control of stereo, left eye and right eye content, 3D audio and backward compatibility with 2D content devices. If the corrections are needed, corrective action must be undertaken until editorial and/or technical approval is received.

Archiving. Approved final product is catalogued and stored in archive. Archiving is one of the most important and most demanding organizational and technical process in whole television production. Among the other things, archival systems can contain and manage metadata archives, low resolution archives as well as archives of still images, effects, sounds and other media related data. Metadata required for archiving purposes can vary depending on the particular circumstances and application and can include identification facts (title, episode title or number, program number, tape location), technical and play out information (running time or 3D digital file format), descriptive metadata (subject, genre, summary), abbreviated production information (director, producer, cast), and initial airdate.

Publication. At some point the program will be ready for consumption and must be prepared for distribution. For a traditional as well as 3D broadcast, the correct file must be identified, scheduled, and made available to the play out system. Play out process allows scheduled showing of the program produced at earlier stages. Programs, whether live or played from archive, are sent to the delivery point (transmitter chain, web etc.). Many 3D content delivery combinations and possibilities exist. Digital terrestrial, cable, satellite, and the Internet all have their own specific needs, usually controlled by the metadata that comes with the file.

Behavioural description of stereoscopic 3d content production

The main objective of a behavioural description is to visualize how the user (represented by the actor) will interact with and use the system. This is done by showing the actor associating with one or more use cases and, additionally, by drawing many use case diagrams. Modelling behavioural description of stereoscopic content production will be considered in three distinct segments: preproduction, production and postproduction.

Preproduction. Main actors in problem space of 3D content preproduction are producer, technical manager and archiving system. Archiving system is an actor which acts also in production and postproduction phases. Use cases important for modelling in problem space of 3D program preproduction are as follows: Research and Develop Idea, Make Storyboard and Stereopsis, Add Preproduction Metadata and Plan Logistic and Staff. Manage and Use Archives is use case which takes a part in all production phases. Use Case diagram of program preproduction is shown in Fig. 2.

Use Case Research and Develop Idea. Short Description: The producer research and develop an idea for production of a 3D program item. Actors: Producer, which can be director or editor. Pre-Conditions: New program schedule is produced and need for fill the slot with 3D content exists. Post-Conditions: Program ideas are investigated, commission results, initial script is made and possibilities for 3D enhancements are considered. Main Flow: (1) Producer suggests an idea for program production. (2) Producer persuades the TV company to finance the conversion of an idea into a real program. (3) Steps (1) to (2) are repeating until commission has been accepted (4) Research is doing, initial script is made, need for 3D item is analysed and

Use Case terminates.

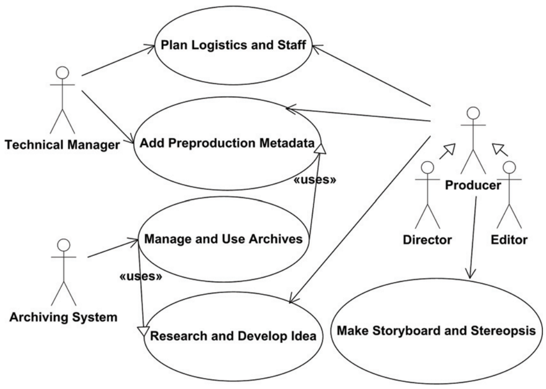

Fig. 2. Use Case Diagram of 3D Preproduction

Use Case Plan Logistics and Stuff. Short Description: Managers plan logistics and staff needed for production of program item. Actors: Producer, Technical manager. Pre-Conditions: Program idea is investigated, commission results, initial script are made and 3D needs and gains are analysed. Post-Conditions: Production order is issued. Main Flow: (1) Producer (Editor, Director) plans the staff needed for production of 3D item. (2) Technical manager plans the logistics (objects, vehicles, production equipment...) needed for production. (3) Producer and technical manager plan the staffing. (4) Production order is issuing for all members of production team. Use Case terminates.

Use Case Make Storyboard and Stereopsis. Short Description: Producer writes storyboard and stereopsis. Actors: Producer. Pre-Conditions: Program idea is investigated, commission results, initial script are made and 3D needs and gains are analysed. Production order is issued. Post-Conditions: Storyboard and stereopsis are made. Main Flow: (1) Producer (Editor, Director) defines the final storyboard based on initial script. Producer makes stereopsis. Use Case terminates.

Use Case Add Preproduction Metadata. Short Description: Producer and technical manager add preproduction metadata. Actors: Producer, Technical Manager. Pre-Conditions: Production order is issued. Post-Conditions: Preproduction metadata added. Main Flow: (1) Producer adds metadata related to preproduction (working title, producer's identity, possibly contributor's names, genre and possibly scripts and stereopsis. (2) Technical Manager adds metadata related to equipment used in project. Use Case terminates.

Production. Main actors in problem space of the 3D program production are producer, archiving system, 3D essence gathering crew (cameraman, sound recorder) and ingest operator. Use cases important for modelling in problem space of program production are as follows: Capture 3D Essence, Ingest 3D Essence, Add Production Metadata, Manage and Use Archives. Use Case diagram of 3D program production phase is shown in Fig. 3.

Use Case Capture 3D Essence. Short Description: 3D video shoots, audio clips and other program items are creating, pre-selecting, and ingesting into production system and logging. Actors: Producer, Cameraman, Sound Recorder, Ingest operator. Pre-Conditions: Production order is issued. Post-Conditions: All essence materials, as well as related metadata, are ingested into production system and logged. Main Flow: (1) Cameraman prepares and adjusts dual-camera system (2) Cameraman takes the 3D shots in studio or terrain. (2) Sound Recorder records the sounds in studio or terrain. (3) Producer chooses the raw material or previously produced essence from archives and repurposes it. (4) Producer reviews what he/she has, and marks down its possible use. Use Case terminates.

Use Case Ingest 3DEssence. Short Description: 3D video shoots, audio clips and other program items are ingesting into production system. Actors: Ingest operator. Pre-Conditions: 3D Essence is captured. Post-Conditions: All essence materials, as well as related metadata, are ingested into production system. Main Flow: (1) All the content collected during a shoot, recording and repurposing is taken and transferred into the production environment. (2) Technical metadata are taken from capturing devices. Descriptive metadata are manually added. Use Case terminates.

Use Case Add Production Metadata. Short Description: Ingest operator add production metadata. Actors: Ingest Operator. Pre-Conditions: 3D Essence is ingested. Post-Conditions: Production metadata added. Main Flow: (1) Technical metadata are taken from capturing devices. (2) Descriptive metadata are manually added. Use Case terminates.

Use Case Manage and Use Archives. Short Description: Cataloguing, storing, search and retrieving program material to/from archives. Actors: Archiving System. Pre-Conditions: Approved access to archives. Post-Conditions: Catalogued and stored essence, as well as related metadata. Essence and metadata retrieved. Main Flow: (1) After ingestion, system catalogues and stores raw 3D essence and related metadata and supports search and retrieving. (2) After processing and control, system catalogues and stores final 3D essence and related metadata and supports search and retrieving. Use Case terminates.

Postproduction. Main actors in problem space of the 3D program postproduction are producer, technical manager, archiving system, processing crew (video and audio editors, animator), publication system (play out and delivery subsystems), as well as the audience. Audience is second-level actor, i.e. it is out of boundaries of the system. Use cases important for modelling in problem space of program production are as follows: Edit 3D Essence, Add Postproduction Metadata, Control, Manage and Use Archives, and Publish. Use Case diagram of program production is shown in Fig. 4.

Use Case Edit 3D Essence. Short Description: 3D shoots, audio clips, sounds and previously assembled content items are put into an order. Actors: Video Editor, Sound Editor, Animator. Pre-Conditions: 3D essence materials and metadata are ingested into production system and logged. Post-Conditions: Essence materials and metadata are finalized. Main Flow: (1) Video Editor makes corrections of both view essences. Video Editor edits the video essence for one view and generates Edit Decision List. Video Editor applies EDL to second view. (2) Sound Editor edits the audio essence. (3) Animator makes the animations, graphics and subtitles in accordance with 3D rules. (4) Video Editor assembles and renders final 3D essence. (5) Use Case terminates.

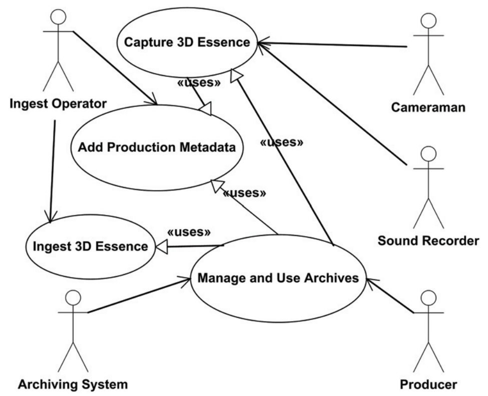

Fig. 3. Use Case Diagram of 3D Production

Use Case Add Postproduction Metadata. Short Description: Processing crew add descriptive metadata. Actors: Video Editor, Sound Editor, Animator. Pre-Conditions: 3D Essence is edited and finalised. Post-Conditions: Postproduction metadata added. Main Flow: (1) Descriptive metadata are manually added. Use Case terminates.

Use Case Control. Short Description: Editorial and technical acceptances approve the use of the post produced 3D program item. Actors: Producer, Technical Manager. Pre-Conditions: 3D essence, as well as related metadata, is finalized. Post-Conditions: 3D essence, as well as related metadata, is approved. 3D content is stored in archive. Main Flow: (1) Editor-in-chef checks and approves or disapproves the editorial quality of the produced material. (2) Technical Manager checks and approves or disapproves the technical quality of the produced material. (3) If the corrections are needed, corrective actions must be undertaken [A1]. (4) Steps (1) to (3) are repeated until the produced material is accepted and Use Case terminates. Alternate Flow: (A1) No need for corrections. Program material is approved. Use Case terminates.

Use Case Publish. Short Description: Play out, distribution and transmission of program. Actors: Publication System. Pre-Conditions: Program prepared and approved. Post-Conditions: Program transmitted/delivered. Main Flow: (1) Program play out. (2) Program distribution. (3) Program transmission using terrestrial, cable, satellite transmission or web delivery. Use Case terminates.

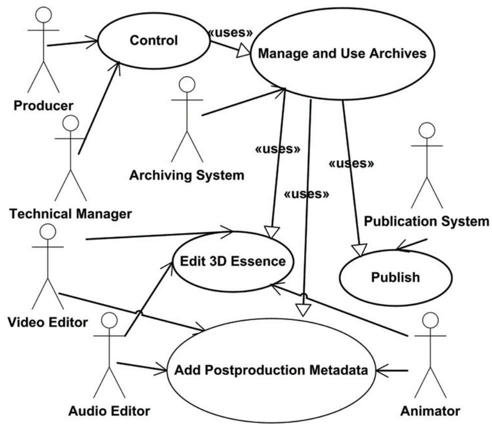

Fig. 4. Use Case Diagram of 3D Postproduction

Model of structural static representation

The objective of modelling structural static representation is to represent, in one or more views, various business entities and their relationships in MOPS. Class diagrams, by their very nature, are very strong, structural, static representations. Class diagram of the 3D program production business process, derived from the previous analyse, is shown in Fig. 5.

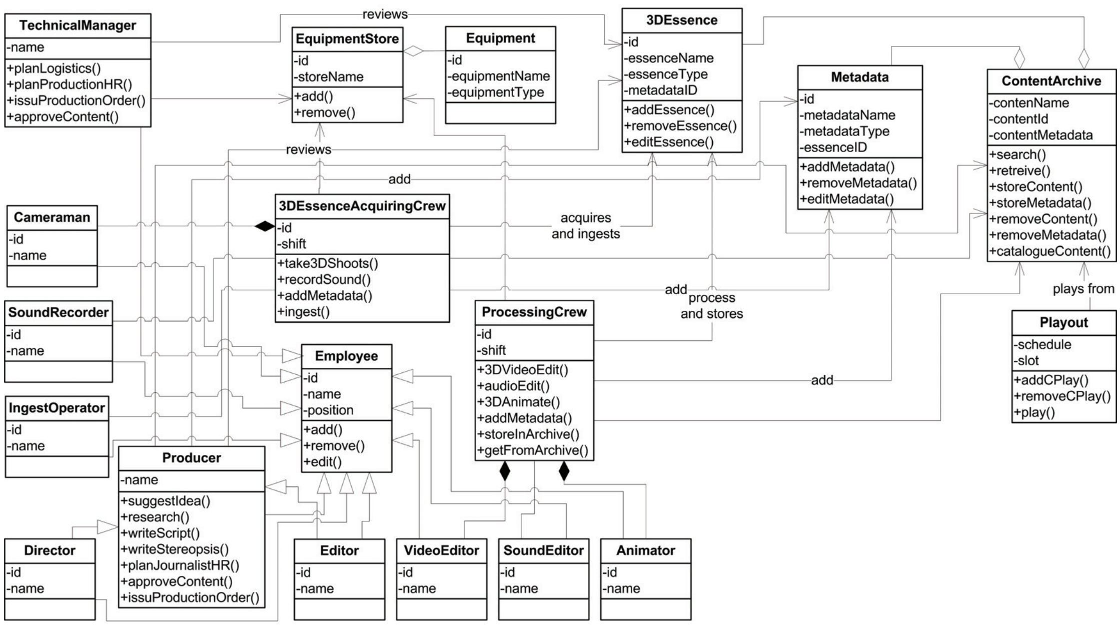

Fig. 5. Domain Model (Class Diagram) of First Generation Stereoscopic 3D Programme Production

Conclusions

Low-budget television broadcasters recently faced with significant financial temptations during the digital turnover in broadcasting industry. It is sensibly to assume that they are not ready in this moment to invest in new equipment necessary for production of 3D content.

The primary aim of this paper is to motivate low-budget broadcasters to reconsider alternatives of partial in-house developments of 3D production process. To achieve this goal, broadcasters have to complete re-think of the way technology can be applied to the art and business of 3D program making. This paper describe the main areas in a 3D TV production environment and summarize the essence, metadata and control flow, as well as the main processes involved in a low-budget 3D television facility.

The first step was to describe the whole 3D TV content production chain. The second step was to propose one 3D TV production workflow and to define one domain model applicable in low-budget 3D broadcasting. Modelling in problem space is used as a research method in this paper. The challenge for the future is to make the model of solution space, as well as the model of background space of the 3D television production.

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Primary aim of this paper is to propose one model-driven approach of software-intensive 3D TV production system applicable and suitable for low-budget broadcasters. The target of the project is to Fig. out one of possible future scenarios for implementing stereoscopic 3D technologies in low-budget TV production and to propose one domain model suitable for further expansion. Modelling in problem space is used as a research method in this paper and first step in modelling of software-intensive 3D television production is presented here. Behavioural description of program production is modelled by the use case diagrams. Domain model is defined and class diagram is used to describe structural static representation the low-budget 3D content production. Ill. 5, bibl. 12 (in English; abstracts in English and Lithuanian).

A. Spasic, D. Jankovic. Mažo biudžeto pirmos kartos stereoskopinės 3D televizijos produkcijos domeno modelis // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2012. – Nr. 3(119). – P. 75–80.

Darbo tikslas pasiūlyti vieno modelio būdą programinei 3D televizijos produkcijos sistemai, tinkančiai mažo biudžeto transliuotojams. Projekto uždavinys išskirti vieną iš galimų stereoskopinių 3D technologijų įdiegimo į mažo biudžeto TV produkciją ateities scenarijų ir pasiūlyti vieno domeno modelį, tinkamą toliau plėsti. Kaip tyrimų metodas panaudotas modeliavimas problemų erdvėje. Pateikiamas pirmasis etapas 3D televizijos produkcijos modeliavimo. Programos produkcijos elgsenos aprašymas modeliuojamas naudojant atvejų diagramas. Apibrėžtas domeno modelis. 3D turinio produkcijai struktūriškai statiškai aprašyti panaudota klasių diagrama. Il. 5, bibl. 12 (anglų kalba; santraukos anglų ir lietuvių k.).