INSTITUTE OF CONTROL AND SYSTEM RESEARCH BULGARIAN ACADEMY OF SCIENCES

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The Institute of Control and System Research (ICSR) at the Bulgarian Academy of Sciences carries out scientific research on the problems of control, analysis and modeling of complex processes and systems.

The Institute consist of seven departments and laboratories:

1. Knowledge Based Control Systems

Field of Research: Synthesis and analysis of multilevel decentralized intelligent control systems, fuzzy control systems, neural networks and structures for control, management of research/design projects, intelligent monitoring and diagnostic systems for autonomous moving objects.

Department Head: Assoc. Prof. Valentine PENEV, Ph.D.

2. Sensor Systems and Modeling

Field of Research: Microsensors, intelligent sensor systems, microsystem technologies, non-contact automation, hardware and software for system applications in automotive, medical, environmental, security, energetics, multimedia and others. Numeric modeling of technological processes, system analysis and identification of technological processes and systems.

Department Head: Prof. Chavdar ROUMENIN, Ph.D., D.Sc.

3. Optimal Control

Field of Research: Modeling and intelligent motion control of autonomous dynamic objects via learning structures and parallel transputer nets, methods for unconditional and conditional optimization, state estimation of dynamic objects, Kalman filtering, association, integration and data fusion from sensory information systems.

Department Head: Assoc. Prof. Ognian MANOLOV, Ph.D.

4. Adaptive and Robust Control

Field of Research: Design of models for biotechnological processes: deterministic, fuzzy, and memory-based models, development of biological state observers, methods and algorithms for on-line estimation of biological variables and parameters including time delay, development of methods and algorithms for robust and adaptive control for biotechnological processes, including time delay systems and sliding mode control.

Department Head: Assoc. Prof. Trayana PATARINSKA, Ph.D.

5. Hybrid Systems and Management

Field of Research: Analysis and synthesis of complex control systems, computer-integrated control systems, distributed intelligence control systems, integrated control and management systems. Artificial and hybrid (human-computer) intelligence control systems, modeling of the human-operator, cognitive task analysis in hybrid intelligence systems, cognitive modeling for adaptive interface design, on-line task allocation in hybrid intelligence systems. Investigation and design of hardware and software for control systems, sensors and sensor systems, automation for scientific experimentation, electromagnetic compatibility in control systems, information and control systems in the National Power System, fuzzy regulators.

Department Head: Assoc. Prof. Dimcho BOYADJIEV

6. Research and Development of Technical Systems

Field of Research: Information security systems for distributed objects, radiochannel computer communications, stationary and mobile ecological monitoring systems.

Department Head: Assoc. Prof. Ivanka VIDENOVA, Ph.D.

7. Scientific Research Applications and Training – Plovdiv

Field of Research: Computer-aided design in machine construction, automated systems for information processing and control.

Department Head: Assoc. Prof. Hristo VARBANOV, Ph.D.

Actively involved in defense and security related research in modeling and simulation is the

DEPARTMENT OF "KNOWLEDGE BASED CONTROL SYSTEMS"

Sample of accomplished projects

- AntiTank Wire-Guided Missile Simulator /ATGMS/
- Tank gun simulator for T-55
- Flight simulator
- Simulator for Paraglider
- Fuzzy controlled autopilot for paraglider
- Fuzzy control for missile
- Digital Servo controller for DC motor with position and speed control on Intel 8051 (C and assembler)
- Digital servo controller for stepper motor with position and speed control on Intel 8051 (C and assembler)

Modeling of dynamic characteristics of moving platforms

For modeling dynamical characteristics of moving platforms we six or more nonlinear equations which describe linear and angular positions of rigid body in 3D space with 6 degrees of freedom. We rely on adequate dynamical models for Fagot missile, F-18, Cessna, Mig 21. Reconfigurable flight dynamics is presented in every application..

Analysis and synthesis of control loops for moving platforms

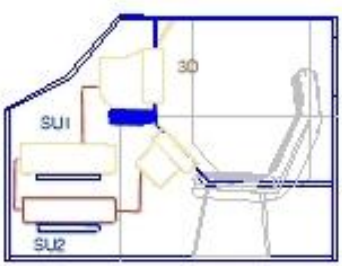
The control loops of our moving platforms were designed on the base of fuzzy control theory. Fuzzy control as an approach to nonlinear and complex control design has attracted a great deal of research interest in the past decade. The basic idea of the approach is to incorporate fuzzy IF-THEN rules into the control design, that is, fuzzy control combines two resources: input-output data and the experts' experience expressed by rules. Therefore, fuzzy control is always applied to the system, which is too complex to get the mathematical model precisely. The autopilot design for flying objects, which are highly nonlinear-coupled system, is good place to implement fuzzy control. Usually we apply fuzzy control in two general ways. First one is to use only fuzzy controller. The second one is to use fuzzy rules like tuning machine for original controllers. Of course, fuzzy control is not a tool, which can be applied everywhere. Therefore, we use fuzzy rules coupled with the transfer functions. We have developed original and elegant approaches to parametric and structural tuning of control loops.

Visualization and final design of 3D simulation software

Currently, we are developing simulation programs under Windows 95, 98 with Visual C++ 5.0 and Microsoft SDK DirectX 3 and ActiveX. We can encompass the whole process of the simulator creation including the following:

- To create the sensation of real combat conditions the computer simulation display is used. Because the system uses actual background terrain pictures, a variety of realistic environments from the desert to winter scene can be used. A number of ground features such as buildings, rivers, threes, etc., may be incorporated. The visual display simulation of weather, with particularly good representation of scud, fog are presented. Terrain is created by 3DStudio and 3D Max.
- Moving objects were designed by 3D Studio and 3D Max. The following items are presented: fighters F-4, 15, 16, 18 Mig-21, 23, 25, 27, 29, Su-27; B-1 bomber; anti-tank helicopters: AH-64, Mi-24, Mi-28; transport helicopters: K28, UH-60; armored vehicles; tanks: T-55, T-80, M1-Abrams, Merkava; missile launchers: "Squd".
- Audio equipment realistically replicates engine and weapon sounds and 3D sound effects may be implemented in software.
- Developing the software for simulators. In our application we use Direct3D, which is Microsoft's real-time, interactive 3D technology for mainstream computer users on the desktop and the Internet. Above all, Direct3D is designed for speed. Direct3D provides the API services and device independence required by developers, delivers a common driver model for hardware vendors, enables turnkey 3D solutions to be offered by PC manufacturers, and makes it easy for end-users to add high-end 3D to their systems. Because the system requires little memory, it runs well on most of the installed base of computer systems. Direct3D is a complete set of real-time 3D graphics services that delivers fast software-based rendering of the full 3D rendering pipeline (transformations, lighting, and rasterization) and transparent access to hardware acceleration. API services include an integrated high-level Retained-Mode and low-level Immediate-Mode API, and support for other systems that might use Direct3D to gain access to 3D hardware acceleration. Direct3D is fully scalable, enabling all or part of the 3D rendering pipeline to be accelerated by hardware. Direct3D exposes advanced graphics capabilities of 3D hardware accelerators, including z-buffering, antialiasing, alpha blending, mipmapping, atmospheric effects, and perspective-correct texture mapping. Tight integration with other DirectX technologies enables Direct3D to deliver such advanced features as video mapping, hardware 3D rendering in 2D overlay planes—and even sprites—providing seamless use of 2D and 3D graphics in interactive media titles.

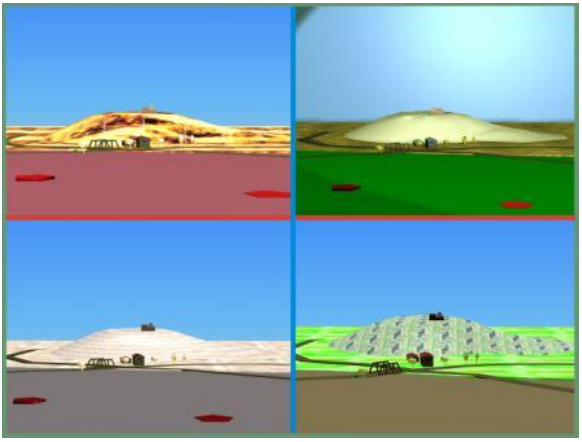
Direct3D is implemented in two distinctly different modes: Retained Mode, a high-level API in which the application retains the graphics data, and Immediate Mode, a low-level API in which the application explicitly streams the data out to an execute buffer.

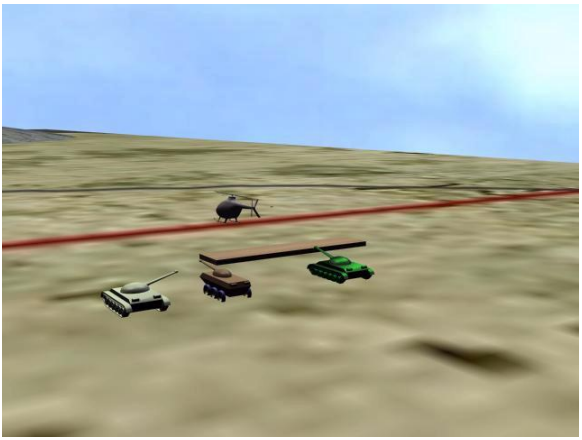


Especially for flight simulator we have a good set of flight instruments for visual and dead reckoning navigation practice. For example artificial horizon, airspeed indicator, turn indicator, inclinometer position of the throttle, altimeter, vertical speed indicator can be used depending on situations. Flight panel is realized on the single computer and 3-D environment on the second with TCP/IP. Flight simulators may be connected into group work system.

Also, we can develop the following kinds of software "Scenario maker" and "Tactical and Technical Characteristics Evaluator", which are useful tools for creating tactical scenario and evaluation of tactical and technical skills of crew.

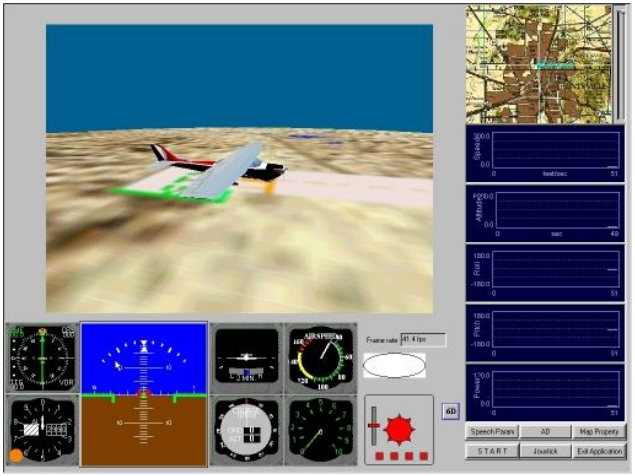
Some background terrain pictures from the screen





Some of the moving objects

Screen view from the flight simulator



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