Training of robots' operators with use of multirobot simulators
Communication on the work in progress

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Abstract
Training of operators of mobile devices with use of computer trainers-simulators is a widely used method nowadays. This approach is applied with reference to unmanned remote-controlled vehicles (UGVs, UAVs, USVs) as well. Typical simulator allows training of one operator at the given moment of time. But in many critical situations (like CBRNE threads, terrorist attacks, natural disasters- hurricanes, earthquakes etc) task to be done should be performed by a set of cooperating robots. Thus, training of robots' operators acting together is a must. Multirobot simulator described in the paper allows training of a group of operators cooperating at the given moment of time.

Simulators – computer trainers

History of use of simulators for training of mobile machines operators numbers about 100 years – first, mechanical simulators of airplanes for pilots' training appeared in the first decade of 1900s. Soon "electrification" of simulators ensued, and since 1960s computers have entered the air simulators field.

Now, computer simulators are in use also for training of automobile and train drivers, heavy equipment operators, for maritime training (among others for training of maritime pilots), for military training with arms and combat equipment, and many others. There are two main reasons of simulators use for training. First of them is the possibility to create extraordinary and dangerous situations in the virtual environment of simulator and repeatedly, step-by-step to train way-out. The second is the possibility of training cost reduction – even by 40% [1], [2].

The same concerns PC-based simulators for robots, which are more and more popular both for professional training and for entertainment. Majority of simulators on the market are designed for a single user. In [3] development of an software environment for simulation of UGV of different sizes "from microbots to teleoperated tanks" is presented. At present [4] simulation for training in operation of a group of UGVs is the subject of interest and work. This is exactly the same in the case of the application of robots in many critical situations (like CBRNE threads, terrorist attacks, natural disasters- hurricanes, earthquakes). Frequently tasks to be done should be performed by a set of cooperating robots. Thus, training of robots' operators acting together is a must. Multirobot simulator described in the paper allows training of a group of operators cooperating at the given moment of time.

Single robot simulators

Methodology of training based on simulators consists of two levels.
First level, introductory, is based on studies of robot's documentation, complemented with lectures, including computer presentations and video materials.

Second level is performed with use of simulators. In Fig. 1. an architecture of a typical single robot simulator is presented.

Virtual reality (or even augmented reality) and 3D technologies are applied for models of a given robot, a virtual environment and a control console. In some cases real console may be used as well. In general, training is performed on PC-class computers (desktops or laptops).
Model of a virtual robot acting in virtual environment with virtual objects is presented on a computer screen. A trainee – a robot's operator – performs his activity controlling robot with use of a console.

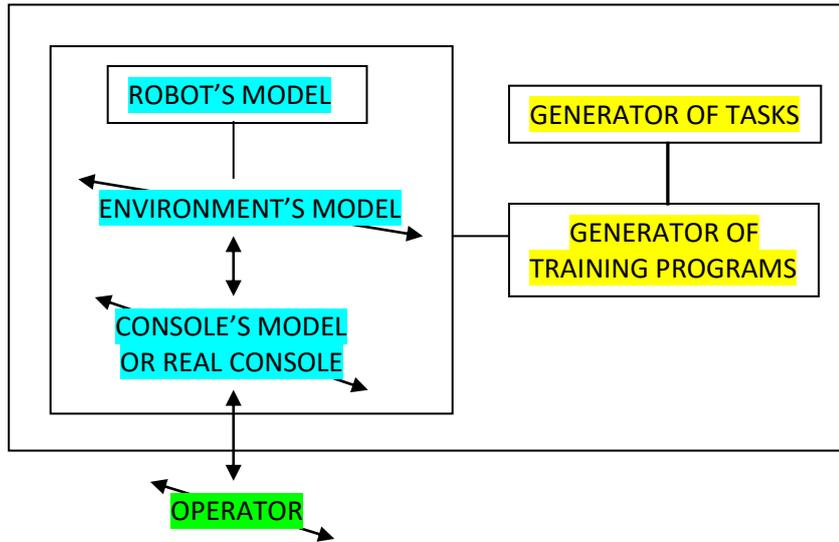Only one operator may be trained on a simulator at the given moment.

Fig. 1. Architecture of a single robot simulator

Training is organized by a trainer (an educator) – person responsible for organization, preparation, supervision and evaluation of training's results. A simulator performs an *intelligent training*:

- a trainee has to fulfill a *training program*, elaborated by a trainer, which consists of a set of *tasks* (training exercises of computer game type),

- a trainer assigns grades-points (usually different) to any task and defines a graph of a training program – a sequence of tasks to be performed by a trainee and *conditions*, which define whether to continue, repeat or finish a program (this is decided by a computer, based on results obtained by the trainee during the training),

- a trainee performs due operations controlling a robots' model with use of a control console,

- a simulator supervises the correctness of trainee's operation, evaluates the performance of a given exercise (taking into account precision, speed etc) and grants accordingly grades (points),

- at the end of a training, simulator provides a final score (in points), time taken for any task and a list of errors.

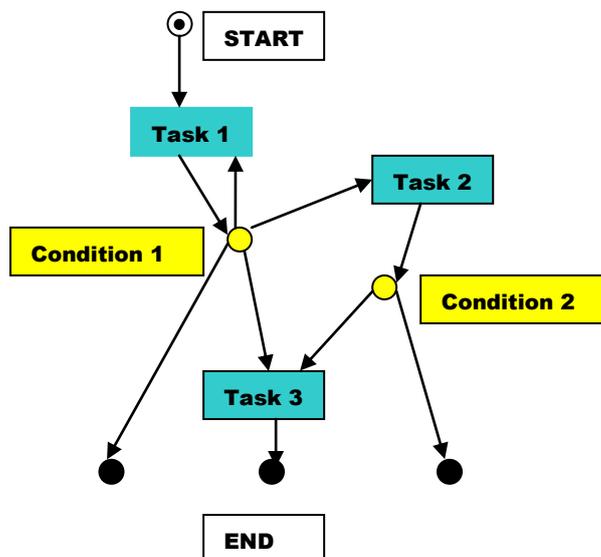Example of a training program's graph is depicted in Fig. 2.

Fig. 2. Example of a training program's graph

This type of intelligent training process may be the basis for operator's certification.

In Fig. 3 there is an exemplary view of operator's console screen during a simulation run.

Fig. 3. Sample of a single robot's screen.

It is worth to note, that if a simulator contains virtual control console training may be performed via Internet.

Multirobot simulators

In case of tasks that have to be performed by cooperating robots, **additional, third level** of training is necessary - with use of multirobot simulators. The idea is to train simultaneously a group of trainees while performing a task that need mutual cooperation and coordination.

An architecture of a multirobot simulator elaborated within two FP7 programs [5], [6] is presented in Fig. 4. The simulator is developed in a server-client architecture on PC-class desktop. All physics computations are done on a server. As physics engine Vortex 6.2 software from CM-Labs company [7] was used. All virtual UGVs are placed in the same virtual environment. Client applications (UGV's console – cameras' viewer and joystick) are connected to a server via Ethernet. Up to ten UGVs' models may be used in training. The simulator allows interaction of several UGVs; UGV's operators can perform tasks cooperatively. Actions performed by up to ten operators are simultaneously presented on a same screen.

An intelligent training, as described for single robot simulators, is realised. Typical scenario of a training exercise in application to e.g. Humanitarian Demining activities, performed by a set of UGVs, is the following: to search a specific object, excavate it from the ground, put into a container and transport to a given place.
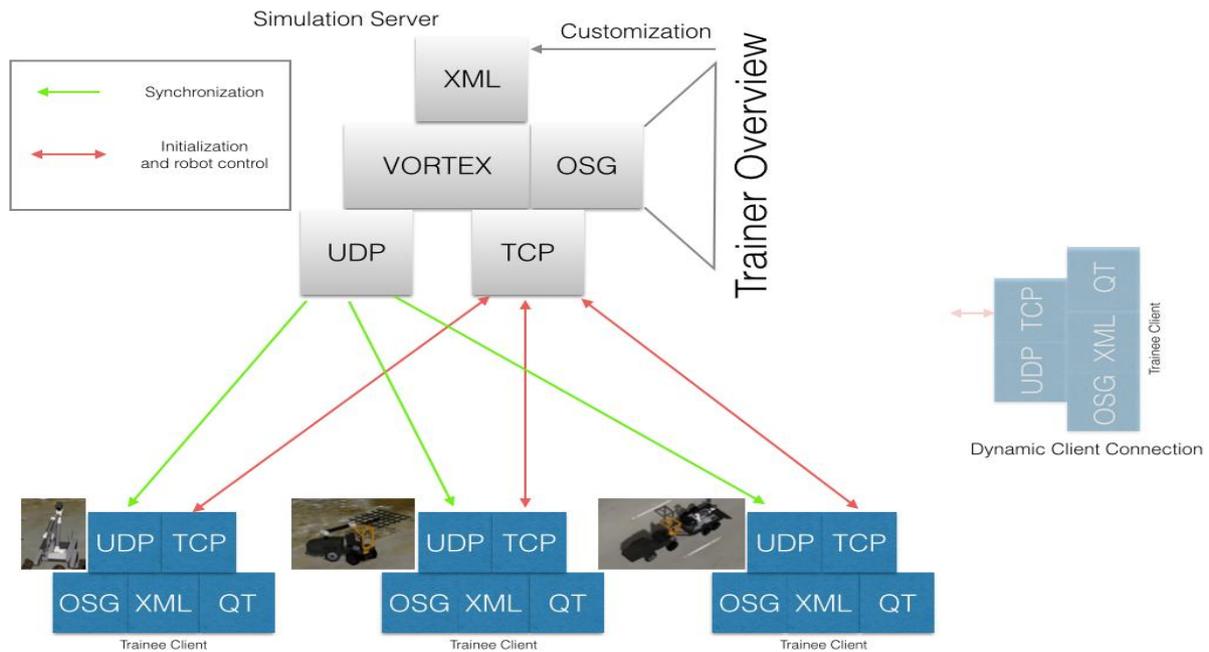
Fig. 4. Architecture of a multirobot simulator

Conclusion

Works on the multirobot simulator are continued in different areas:
- new models of different UGV's, based on robots' CAD documentation, are being elaborated, as well as of UAV's and USV's,
- new tool for support trainer's activities – a facility with expanded reporting features, is under way.

Multirobot simulator is an innovation solution, which may be a valuable tool for group training of robots' operators.

References

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