Technology of Computer-Aided Adaptive Camouflage

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Abstract: - The camouflage is concealment by means of disguise. This article deals with a project acronym ADAPTIV of Czech Defence Research Project. This Project solution tends to adaptive camouflage by the Computer - Aided Mimicry (CAM), which is ADAPTIV Project middle-term solution. Perceptive interface between recipient and camouflaged object is visualized by means of textile modular screens. Screen´s special light semi-permeability enables front/ back projection with nearly identical light parameters. Information permeability, towards illusion creation, must be controlled by the camouflage provider by means sophisticated and mastered illusion with perfect scenarios. ADAPTIV´s financial possibilities and COTS principle ask special definition of feasibility conditions, especially recipient space position. All participants of camouflage Use Case have pregnant scenario roles as the technologic system components, domains, actors, agents and art mediators. They all will be introduced especially in military environment in live PowerPoint presentation at the Conference.
Key-words: Computer-Aided Technology Implementation in Adaptive Camouflage.

1   Introduction

This article is a co-product of Czech Defence Research Project, having an acronym ADAPTIV. This multi-branch project solution tends to Adaptive Camouflage by the Computer - Aided Mimicry (CAM) implementing in autonomic outdoor computerised mobile WiMAX net as the workshop place. Here displayed architecture and Use Case of necessary systems and their technologies represent ADAPTIV Project middle-term solution. Perceptive interface between a human recipient i.e. observer eyes/ brain and camouflaged object is visualized by means of special canvas modular screens in dural thin tube construction. Screen´s special light semi-permeability enables front/ back projection with nearly identical light parameters. On this interface, information permeability creation must be controlled towards "true" illusion by the camouflage provider, because antagonistic (enemy) recipient is expected. Just a sophisticated and mastered illusion with perfect scenarios can cheat the rivals. ADAPTIV´s financial possibilities and COTS (Commercial-Off-The-Shelf) principle [1], i.e. the flat character of screens, just a one piece of using commercial data-projector and very short financing resources, they all ask special definition of camouflage recipient (Observer) space position. All participants of adaptive camouflage Use Case have pregnant scenario roles as the technologic system components, domains, actors, agents and mediators. Generally, ***"no so perfect reproduction of reality is the best for better camouflage illusion"***. Frequently, the "smash / fuzzy/ defocusing" contours on screen interfaces create more superior illusion for enemy eyes and brains. Even, the interfaces between potential enemies ask illusion scenario having ad hoc scenery shift forward and/or back in real time, which is above computer abilities, because it is on an art level. For this reason here, it is not enough a clear cybernetic system, even an expert system without artificial intelligence is inoperative. So, this interface needs an assistance and management of human made camouflage art mediator. This art mediator must operationally mediate camouflage virtual image in real time/ space/ environment according event or situation change and/or according illusion libretto requirements on camouflage scene. CAM adaptive camouflage, implementing virtual image operating in visible range of electromagnetic wave spectrum using data projector for projection of image on screen interface in ADAPTIV Project. Above fundamental principles create platforms of CAM adaptive camouflage of Czech University of Defence in research & development Grant solution of National Defence Research. Grant project deals with new adaptive camouflage technology for decoys simulation and camouflage in operational environment of Czech Republic Armed Forces and for infrastructure protection. The resources and "how to" of this Grant asks a finding of new approaches of problems solution, especially in military environment.

 Adaptive camouflage [3] means a capability of an adapting object appearance to match its environment and/or impersonate other object. Adaptive camouflage (or active camouflage) is a group of camouflage technologies which would allow an object to blend into its surroundings by using of panels or coatings capable of changing color or luminosity. Active camouflage can be seen as having the potential to become the perfection of the art of camouflaging things from visual detection.

1.1 Camouflage scenario´s roles

Camouflage scenarios development presupposes necessary using of the computer-aid in up-to-date practice. That is why shall be preferred the DYVELOP© methodology [2] for camouflage scenario modelling and simulations.

The roles, casting of camouflage scenarios, are expressed in next blazonry structure, where the terms are:

Event is a happening or occurrence, especially a dramatization or performance. In framework of Event analysis is necessary specifying exact parameters of scenario design modelling - The occurrence, processes, running, episode, participants, conditions, organization, and performance.

Environment is principal domain. The definition and analysis of principal scenario´s domain - the relevant Environment – ENV [2] is the first step of each scenario creation. It includes scenario object neighbourhood, its circumstances, conditions, possibilities, resources, etc. In the scenario creation, the further domains can be: e.g. the nature, enemy, real time, real space, organization, informational media etc.).

Scene is a framework of relevant event processes. Within the Scene analysis is necessary to close specify exact parameters of scenario objects.

Scenery expresses a framework of instruments, tools, equipment, accessories, sensors, indicators and subsidiary tools of the scene. The scenery analysis includes the subject's roles specification and definition.

Circumstances affect and guide event´s running evaluation.

Map is survey arrangement of scenario entity´s portfolio.

Scenario is an account or synopsis of a projected course of action.

Libretto is a text of a work of semantic roles in the Scenario.

1.2 To do camouflage scenario processes

This activity is represented below mentioned processes. They had formed from well-knitted information chain and technology. Camouflage scenario processes design making consists from next processes entities and their roles definition. Technology is sequentially chained from below seven process steps (see Fig.1), operating in a frame of scenario design and terminating in ADAPTIVE CAMOUFLAGE Use Case. The implementing and testing is emerged in cycling necessity of some/all steps. Right-side is their relevant representation on the Fig. 1.
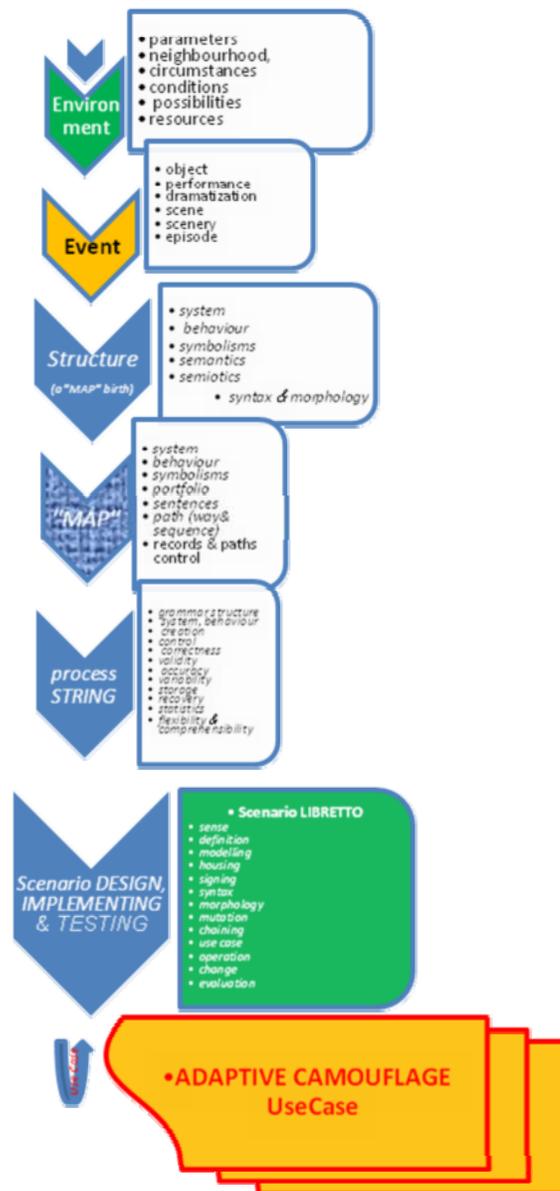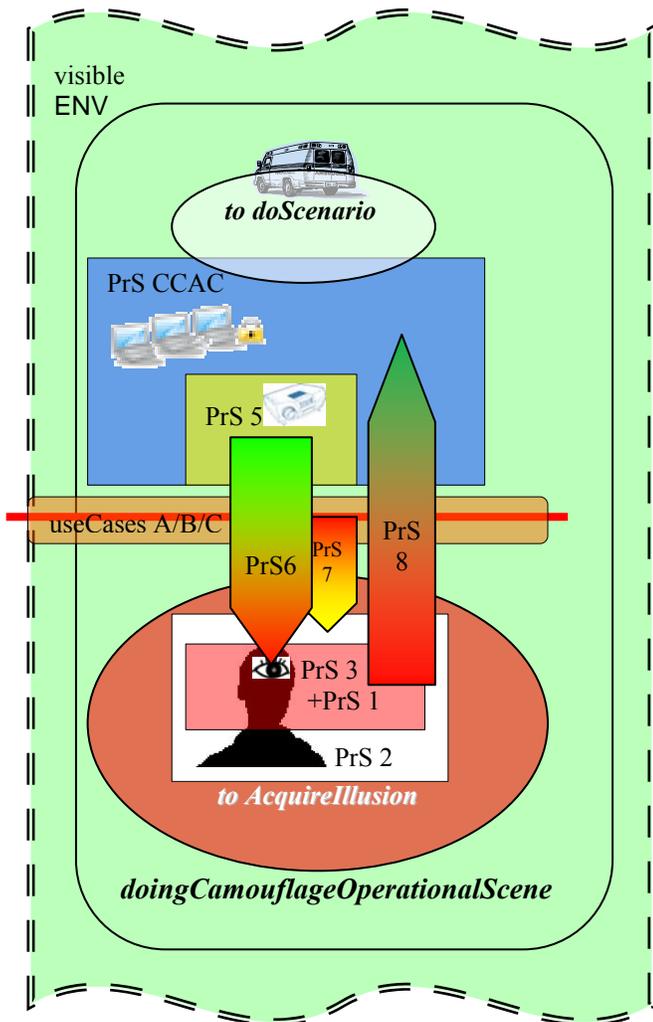

Fig. 1: A string of Camouflage Processes

2 Camouflage Processes Modelling

The processes between relevant entities of Camouflage Use Case, i.e. between the Subjects, Objects and other Players, they are exactly and blazonry modelled via DYVELOP© method [2] Blazons. Abberevation PrS means Process System in the sense simplified formulation of Process Approach [5] of particular systems and entities, casting in adaptive camouflage operation. Mutual relations and incidences of participated entities are expressed in the Blazon at Fig. 2. It shows graphically key process systems (PrSs) and their interactions and relationships described in following Table I. Here, perceived **Illusions** are most important physical – physiological - psychological phenomena, impacting a **Recipient** (his symbol is red box PrS 1 on the Fig. 2). Watcher as **espial Observer** (white box PrS 2) is this, who complex feels the illusion like a real property. But, for the Observer in Recipient role, a predisposion must be provided to dupery, mystification and feeling of virtual picture as a real. Whole this process of illusion feeling and camouflage is enacted in visible lights spectrum, which is formulated by an **Envirement** „Visible ENV".

An aim is, to achieve terminal Use Case operational fiction *„making Camouflage Operational Scene"*, which is giving to quasi stationary distant Recipient, which feels offering Illusion on red critical **Interface** line (real combinations of useCases A/B/C screens) at Fig. 2 Blazon. He is feeling camouflage scenery as real property. He can anticipate a disguise, but definitely, he does not know, what is behind of herewith Interface as real object. The target of camouflage Illusion is there human perceptive espial Observer in its camouflage Recipient role, which is expressed in Table 1/ Fig.2.

The **Camouflage Computerized Aid/ Control System** (see below PrS CCAC) is technical provider of camouflage Illusion, which needs necessary human **Art Mediator Expert** as an **Operator** in scenario **Designer** role (see Fig. 1). The camouflage imaging **Scene** is created by components, domains, actors, agents and mediators. Vsible **Object** is covered by camouflage Illusion projected on imaging **Screens,** using in useCases A/B/C shape configurations. Targeting agent of camouflage processes, intermediating light physical processes perception, is enemy espatial Observer (see PrS 2) always. The function of Observer´s **Eye** (see PrS 3) is relative heavy deceivable, while **Observer´s Brian** is here the most inclinable to a mystification as regulative, control and evaluative **Actor** of camouflage process Scene. He is impacted by operational function: *to Acquire an Illusion*.

Fig. 2: Operational Blazon of Camouflage Processes Relations

Table 1: Entity´s		
	semantics	determination
	Object of Camouflage	Principal entity
visible ENV	Environment of Visible Camouflage	Visible light domain
PrS CCAC	Camouflage Computerized Aid Control and Expert System for Art Mediator	3 notebooks in local net, SW CAMouflage Plus providing final illusion by
PrS 1	Recipient	process system of enemy actor
PrS 2	Espial Observer	via Observer´s eyes→ brain
PrS 3	Observer´s Eye	human eye
PrS 4	Screen of front and back projection	canvas surface 2,2 x 2,2 m
PrS 5	Dataprojector	Sanyo PLC-XP200L
PrS 6	Virtual Light Image	light flow
PrS 7	Information flow	light perception
PrS 8	Information Feed Back & Reflection from PrS1	indicating behaviour
to doScenario	to Create Scenario of Camouflage	operational function
to AcquireIllusion	to Percept Illusion	Observer acquires the illusion
useCase A	Visualization of Luminous Flow on 4 Screens modular figuration type A	functional use case for wide object covering
useCase B	Visualization of luminous flow on 4 Screens modular figuration type B	functional use case for square object covering
useCase C	Visualization of luminous flow on 4 Screens modular figuration type C	functional use case for high object covering
UseCase: making CamouflageOperationalScene	Doing ROLE of Camouflage Operational Scene Designer+Maker	human Art Mediator Expert doing scenario Design + Operation
INTERFACE HW	Mediator for Human Recipient	canvas (textile) imaging screens

A disseminator of this Illusion is whole the *Use Case: doing Camouflage Operational Scene,* including all above relevant entities, operating into defined Environment of visible camouflage: the **visible ENV** (see Table 1/ Fig.1). Important further **Mediator** of this Illusion is PrS 4: **imaging Screen,** enabling front and back projection of **Virtual Light Image** (see PrS 6) and its perception as an **Information** (see PrS 7), perceptible by the Recipient. Generally, imaging Screen can be arbitrary Interface, enabling 2D/ 3D projection (cinerama, screen, monitor, foam, smoke ...). Imaging (displaying) Screen is crucial means for a deception of the Recipient (PrS 1). In the domain of visible spectrum environment (visibleENV), the processes emerging by

the use case function: „*making CamouflageOperationalScene*" is made by various numbers of infrastructural components, domains, actors, mediators and participants. But, from the point of view of deceitful or tricky camouflage processes – they are controlled by a **Scenario** in the role of operational function *to do Scenario*.

Military Adaptive Camouflage needs the sensors of **Information Feed Back & Reflection** from <u>enemy</u> Recipient (PrS1), percepting visual illusion effect = *to Acquire Illusion*. It can be indicated just by a monitoring of enemy PrS1´s **behaviour** in in the domains: visible ENV, real time & space. Cybernetic monitoring and control system of this behaviour can´t be made, in the ADAPTIV Project, for insufficient financial resources.

3 ADAPTIV Project

The survival of human society requires the most effective behaviour aiming to the co-operation, collaboration, integration and technological ascendancy of friendly actors. But vice versa, the security and defence research must offer pertinent means of protection for "native rival´s force" predominance counter antagonists and enemies. A camouflage systems and technologies is one from most important means for it.

The Czech University of Defence R&D Grant of National Defence Research Project with acronym *ADAPTIV* is specially aimed to: *Draft and assertion new adaptive technology for simulation and camouflage in operational environment of Czech Republic Armed Forces and for infrastructure protection.*

ADAPTIV project solution has defined strict conditions which nominatives are a restriction of financial resources and exact definition of Project boundaries and conditions regarding researched and developed systems and technologies:

a/ Observer would be distant (100 m) quasi stationary military person in espial role.

b/ Observer´s sense using for camouflage detection is limited to normal humans vision in visual range of luminous spectrum, without night vision systems, radar, sonar and thermal imaging as well.

c/ Omitting of other senses, such as olfaction (smell), touch, sound and hearing.

d/ Using cybernetic computerized aided technologies and dataprojectors for a visualisation acquired by COTS principle(Commercial Off The Shelf) [1].

e/ Omitting expensive and in the field untried technologies, as the lasers, etc.

3.1 Mid-term Project results

ADAPTIV Project R&D tends towards Adaptive (Active) Camouflage by Computerised Aided Mimicry (CAM) implementations [4], using CAMouflagePlus Technology Scenarios, which must be adaptive to operational Scene, Scenery and Object copys; rendering (intercepting) and /or emitting deceptive (illusory) virtual reality for relevant Object change in military theaters of protective operations. It need building of formalized databases (pictures) and pertinent technology with capabilities of the flexibility, interoperability, integration, Network Enabled Capability (NEC) & Computerized Aided Design (CAD).

By us provided technology offers: A using of the perspectives, research, development, implementation and application of computerized aided technologies, intended for a protection of troop's forces and equipments, of the civilians and technological infrastructure and for the simulation and camouflage of military activities and targets.

3.2 Technology testing in interior environment
Used arrangement
<u>Dataprojector</u>: Sanyo PLC-XP200L; LCD; 7000 ANSI-Lumen; 1600x1200 (UXGA). <u>Photo-apparatus</u> <u>for scene configuration pictures</u>: Canon EOS 350, Video-camera Canon 40i and Camera NICON D3. <u>Interface</u>: canvas surface of imaging screen in 2,2 x 2,2 m solid tube´s frame, possible forward and back projection. <u>Computers</u>: 3 pieces PC (notebook) - for dateprojector image generation; for processing of running record and for process control. <u>Measuring photo-apparatus for camouflage photograph pictures documentation:</u> NICON D3 in the role of PrS 3 "Eye"; pixels 4256 x 2832; resolution 300 dp; bit depth 24; f'objective   70 mm; temporal shutter issue c 6,3; sensitiveness ISO1250; currency speed lamp NICON.
Camouflage scene

Camouflaged object: "a bag postured on a chair"; Scenery: casern hall with „yellow pedestal" (see left part of Figs. 3&4) and „military fish net" in background field, hall ground plan 12 x 12 m, high 6 m. Lighting: 2 pieces discharge lamps 400 V, 50 Hz, 250 watt, gamboge colour, near ceiling; plus supplementary daylight lighting timely variable within the bounds from 10% till 25 % artificial luminous exposure.

Test fundamental physical parameters: An exposition $\underline{\boldsymbol{S}}$ (exposure) is given in (1) a plain of image matrix detector:

$$S = \int_{t_1}^{t_2} E \cdot dt$$
$$[\text{lx.sec}] \qquad (1)$$

where $\underline{\boldsymbol{E}}$ is irradiation and $\underline{\boldsymbol{t}}$ is bottoms up-positional time. A (2) is valid for arbitrary point of matrix detector:

$$E = E_0 \cdot \cos\omega^3 \cdot \cos\omega = \frac{\pi}{4} \cdot L \cdot \tau_{opt} \cdot \frac{1}{c} \cdot \left(\frac{\beta_{0p}}{\beta_{0p} - \beta_0}\right)^2 \cdot \cos\omega^4$$
$$[\text{lx}] \qquad (2)$$

where $\underline{\boldsymbol{E_0}}$ is axial point lighting, $\underline{\boldsymbol{\omega}}$ is ray angle with optical axe, $\underline{\boldsymbol{\tau_{opt}}}$ is a permeability (transmitance) of object-lens optical system, $\underline{\boldsymbol{L}}$ is a brightness (glare) of scanned object, $\underline{\boldsymbol{\beta_{op}}}$ is display scale in lens pupilla and $\underline{\boldsymbol{\beta_o}}$ is display scale (a characteristic of scene configuration).

Test description

For camouflage scene creation was combinated: **virtual picture** from back projected dataprojector (connected and controlled by SW CAMouflage Plus) on one piece of imaging screen; and **real casern hall** with „yellow pedestal" (see left part of Figs. 3&4) including „military fish net" in background field. This scene presentation was evaluated and tuned by our "friendly" human observer visual look firstly in a confrontation with real neighboured environment. Scene veracity, coloured version and objectivity were evaluated. **Vertical boundary-line** of imaging screen ("**thin tube**"↕) between a reality ("yellow pedestal") and displayed camouflage scene was accented. Here, this boundary-line is crucial for our camouflage scene, because "thin tube" visibility can cause camouflage disclosure. The observer, in Art Mediator Expert and camouflage scenario Designer roles, prepares scene revision. He makes the **tuning** for scene exact qualitative evaluation on photograph pictures, firstly displayed on computer screen via technology SW CAMouflage Plus.

4 Conclusions and Interesting Results

The mid-term **tasks** of Computerised Aided Camouflage & Mimicry of R&D Grant ADAPTIV were fully realized.

"thin tube"↕ *Fig. 3: Photo DSC4942*

"yellow pedestal" *Fig. 4: Photo DSC4951*

At Fig. 3 and 4 tuned camouflage scene **illusion** is nearly excellent for the both for the human eyes and for the photograph picture.

A **conformity** is very good of the both: of the back-dataprojected virtual picture on imaging screen, i.e. "bag postured on a chair" &background „military fish net"; and of the neighbourhood of real casern hall with frontal „yelow pedestal" & background „military fish net", on one piece of imaging screen. The "thin tube" creating **solid frame** of imaging screen is nearly invisible.

Interesting camouflage scene reading: DSC4951 photograph picture (see Fig. 4:) **virtual** part on right side from „thin tube ↕", has identical quality as on picture DSC4942. But photograph pictures „**reality**", i.e. the left side part from „thin tube ↕", has top plate of its construction **lighter** in a consequence of **glaring flow fluctuation** from discharge lamps (50Hz frequency).

References:

[1] Perry,W. US State Secretary, *Military Doctrine*, 1994.

[2] Urbánek,J.F. Effective Modelling of Know-How for Cyber-Informatics Practitioners, In *8th Int. Conf. on Simulation, modelling and optimization, SMO '08,* Santander, Spain, WSEAS Press, 2008, pp. 252 - 255, ISBN 978-960-474-007-9, ISSN 1790-2769.

 [3] Urbánek,J.F., Barta,J., Heretik,J. & Průcha,J. Computer Aided Camouflage, In *10th WSEAS Int. Conf. on*

Applied Informatics and Communications, AIC ´10, Taipei, Taiwan, WSEAS Press, 2010, ISBN 978-960-474-216-5, ISSN 1792-460X, ID 609-289, pp 289-294.

[4] Urbánek,J.F et al, Cybernetic Camouflage on Human Recipient - Visual Illusion INTERFACE. In WSEAS/ Europment/ EuroSAM International Conferences; Vouliagmeni, Athens, Greece; 2010, ISBN: 978-960-474-262-2 , ISSN: 1792-7315, pp 22 – 27.

[5] ISO 9001: 2000 (2008)