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Autonomous Input Management for Human Interaction-Oriented Systems Design

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***Abstract*—In this paper evaluation of a policy-based algorithm for video inputs switching is presented. The term 'data quality' is not trivial for Human-Machine Interaction systems, yet a simple and efficient algorithm is needed for choosing the most valuable video source. This becomes particularly important for systems that support functional decomposition of image processing algorithm, which are designed for non-optimal working environment. In this paper an autonomous input management system is proposed, which consists of a data quality evaluation algorithm and a simple decision algorithm.**

Keywords – Human-Machine Interaction (HMI), Machine Vision, Decision Systems, Distributed Systems, Autonomic Systems

I. Introduction

COMPUTER vision has become a popular information source for computer and robotic systems interacting with humans, however the tests were conducted mostly in laboratory conditions. Real-life applications may cause some challenges as various environmental conditions are taken into account, although some biological mechanisms enable to handle both data aquisition and information processing, which exceed the capabilities of a very complex acquisition subsystems, such as – being able to see in the dark or being able to read and understand a text with the majority of illegible letters. Computer systems are supposed not only to entertain but also to support and protect humans, therefore they should contain more efficient, than the human one, information processing system. Possible future implementaion of these acquisition systems with the application of speech and/or vision include inter alia fire rescue teams supporting systems.

II. Policy-Based Input Switching

It is possible to implement all available acquisition systems and to process all the input information (thermal video, night vision), but in real-life applications it is not efficient because the data streams may be too massive and require high computing power for real-time processing in order to enable embedded system-based implementation. Transmission of multiple video streams to a remote workstation/server is also complicated due to the limited bandwidth, however it is possible to choose one input at a time and transmit it (or process it locally) [1], if the system was able to judge the value of the data input quality of its acquisition subsystems. The quality evaluation could be performed on the basis of static threshold values (e.g. any measure of image noise or edges quality), but in that case it would be just a simple condition. The Policy-Based Input Switching (PIS) becomes especially useful when adjusting/changing the policy for choosing an input depending on circumstances or environment. The proposed PIS conception is not a set of rules and threshold values, but an entire framework offering wrapper functionality (similarly to [2]) for additional modularity and as a foundation for autonomous policy reloading/changing. A semi-autonomous mobile robot designed for a fire team support could enable to change its policy for operating in a particular environment and to change its policy autonomously depending on any transient environment parameters.

III. Subjective Quality Evaluation Procedure

The Subjective Quality Evaluation Procedure (SQEP) is implemented in the core of the PIS framework and is able to decide locally on the active input (as a part of policy algorithm) and on the active policy (as a part of wrapper's autonomous module). Whilst the SQEP is intended to be run locally. It should involve only simple and efficient operations for data input evaluation. In a pilot study basic policy was implemented for choosing the best visual data input out of three available inputs: (1) video stream, (2) night vision, (3) thermography. The exemplary SQEP was implemented to choose between (1) and (2) basing on brightness and noise and then between (1|2) and (3) basing on the width of histogram of (1|2). Fig. 1 shows the value of a quality coefficient calculated for two different acquisition subsystems, acquiring visual information of the same scene and objects and in the same temporal context. Acquisition starts in darkness, and c.a. 128th frame a dim light source is turned on. The light is bright enough to turn off the infrared lighting, but not bright enough for the computer vision camera to acquire data of good quality. It is highly beneficial to have a SQEP procedure implemented in the PIS system, where the algorithm of a policy (and its rules or conditions, parameters and decisions) is intended to be easily replaceable and changable at runtime, without any modifications to the inputs and outputs of PIS policy wrapper. The wrapper's functionality is extended to support autonomous policy exchange.

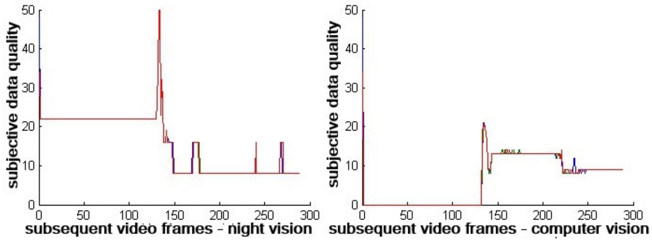

Fig. 1. Compartment of two acquisition subsystems, showing data quality during a change of lighting in the scene.

IV. SQEP for Autonomous Input Management

The main goal of using the proposed framework is to extend the functionality, versatility and robustness of the acquisition subsystems of vision-based mobile robots. It can only be achieved if the outputs of the Acquisition Subsystems and the outputs of PIS system will be developed to become modular and replaceable, so the Subjective Quality Evaluation Procedure (SQEP) should handle the evaluation of all inputs available in the hardware and all possible combinations (subsets) of these inputs and to produce the same set of predefined output variables and data structures. The SQEP should offer not only the possibility of on-demand input switching, but most of all it should perform the input selection procedures autonomously, if there is a better data quality input than the currently processed one. The decision about which input to process should be done locally to prevent transmitting of all data inputs to remote servers and the inputs should be evaluated in a simplest possible way to save the CPU cycles of local/mobile/embedded system. The most important feature of SQEP is the capability of autonomous data quality evaluation. Only one input is being transmitted and the most valuable data input is connected to the Cognitive/Decision System at a time. The coefficients and rules (the algorithm) of input quality evaluation can be changed at runtime by PIS system.

V. PIS for Autonomous Policy Management

The SQEP has proven to be useful, as it is beneficial in order to stay connected to a good data quality input, even in a changing environment. The basic PIS functionality is the possibility to change selection criterions – the policy, such as different environments as a very attractive feature. The most useful feature of PIS system, however, is the possibility to change the selection criteria in runtime (without rewriting the code, compiling, uploading, running). Thus there is no need to interrupt learning/execution or to reset the system's memory/knowledge/execution. The PIS system, in its most sophisticated version is expected to enable changing its policy 'intentionally'. In some cases it has very little effect on a mobile system, but sometimes it may be crucial feature for the accomplishment of the horizontal goal of the system.

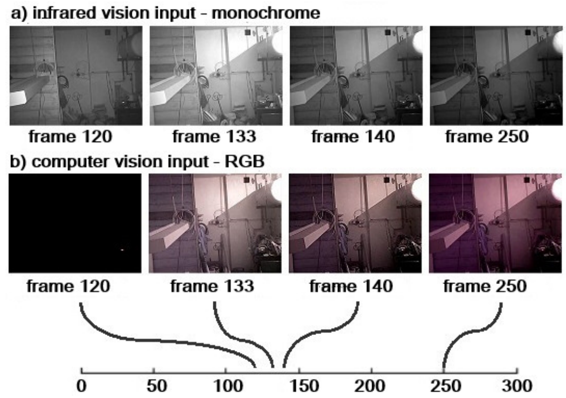

Fig. 2. The exemplary visual data input: darkness (frame 1..127) and with a dim light turned on (frame 128..288). Frames 128..140 are too bright due to the automatic white balance feature.

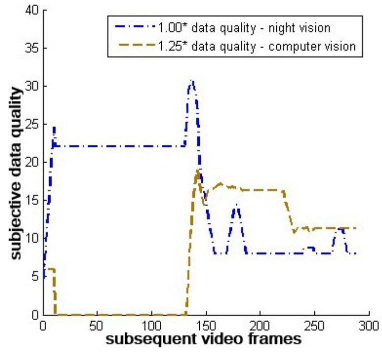

Fig. 3. An exemplary simple data quality coefficient for SQEP system for a policy-based input switching system, during a change of lighting in the scene.

VI. Advantages for HMI Systems, Future Work

Future work will implement inter alia virtual agents [3] and bio-signals. Use of virtual agents would make the system more intuitive. Initial tests were run with the application of the face mimic and the Emotiv EPOC headset. Future work will also involve development of a standalone application (AE) connecting Emotiv EPOC headset with any embedded platform. The work will be advanced by implementing various bio-signals [4]. The proposed control architecture should also be improved in order to reduce appearance of potential control errors, which is a common issue in autonomic systems.

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