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Invented for life

Ensuring New Age Digital Experiences Come Alive
HMI Testing In Action

HMI
A critical element
For A Great Consumer Experience
with Product & the Product Company

HMI in layman terms is a "simple interface" which enables a user to interact with machine systems. The machine system could be as simple as a display mounted on a product or seamless as in a mainframe based control UI or a smartphone.

Designing interactive products to support the way people communicate with machines in their daily lives is a fast growing and multi-disciplinary field. The information architecture around this interactive design is a result of research and analysis of many patterns of human behavior.

They are quite diverse and are influenced by many factors like region, language, culture, domain and many other parameters. The range of technological developments has encouraged different ways of thinking about interfacing with machine viz. innovative ways of controlling and interacting with digital information include gesture-based, touch–based and even brain-computer interactions. There are combinations of digital and physical world culminating into new ways of interactions like mixed realities, augmented realities, tangible interfaces and wearable computing.

A major proliferation thrust for HMI is the fact that transformation is far beyond individual user but supporting large scale social interactions for people on the move, at home and at work. Some recent applications in I4.0 has focused on merging a few of these HMI technologies where-in industries like textile uses wearable displays like gloves to keep track and show user their schedule for the day, a wearable embedded with sensors which follow the body of the wearer to capture movements and interactions with machines.

They are then displayed through electroluminescent surface creating halo around to consume the information.

Eventually these HMI techniques demand intense validation methods to match the real time needs. With such a massive and disruptive advancements in technology, lack of right HMI test validation tools may be throttling the pace of product development.

HMI Testing
An industry context

A system which validates categories of advanced Natural User interfaces (NUI) like gestures, voice control inputs & massive graphics needs to be versatile. The system needs to be co-existing in order to understand the context in which these products interact with real world. A system to validate such a product needs to be equally adaptive and responsive to the quick changes and evolutions in the technology.

Some of the available test solutions in the market which enables testing of graphics in market have below technical drawbacks:

Inability to benchmark consistent identification of defects with **pixel perfect** accuracy against the referenced requirements or User design. Most of these systems need golden samples and make comparisons offline.

Language translators work only with the verification of number of characters within a specified layout design. This does not consider the underlying platform font engine (Eg Ricoh type, free type etc.) behaviors which directly influence the width and height of a rendered character on the display device. Thus the testers spend a lot of time in identifying issues due to lack of test systems being intelligent and **adaptive enough for cross platform designs**. Lot of time is spent in writing localized scripts to perform such verifications which include instrumentation while testing.

The test system is expected to be highly competitive in order to match the human capabilities offering inputs to the system. The inability to meet the **time latency** requirements while providing and process inputs, has led to a lot of leaked defects due in extreme real time performance conditions.

Most of the HMI technology has an event driven architecture. One of the critical challenges to be solved is the **responsiveness**. A test suite with an ability to include diverse input generation possibilities is very critical. Most of the test systems are unable to detect the untimeliness in complex animations and video rendering use cases.

Even simple interfaces have a large variety of **real time attributes** to be verified. Eg : Button may have visual attributes , voice interface may need tone , pitch & volume validations, Gesture input may need filter tests , power to verify faulty user interventions etc. A test suite powerful enough to generate such natural inputs in all forms is missing in total.

HMI Testing
A Bosch Approach

At Bosch we solve this puzzle with a quite ubiquitous technique. Various testing methods are integrated to our HMI test system including Usability, Validation & Security.

"Our system has a built-in eye to keep watch, intelligence to sense and classify, brain to learn & arms to act upon"
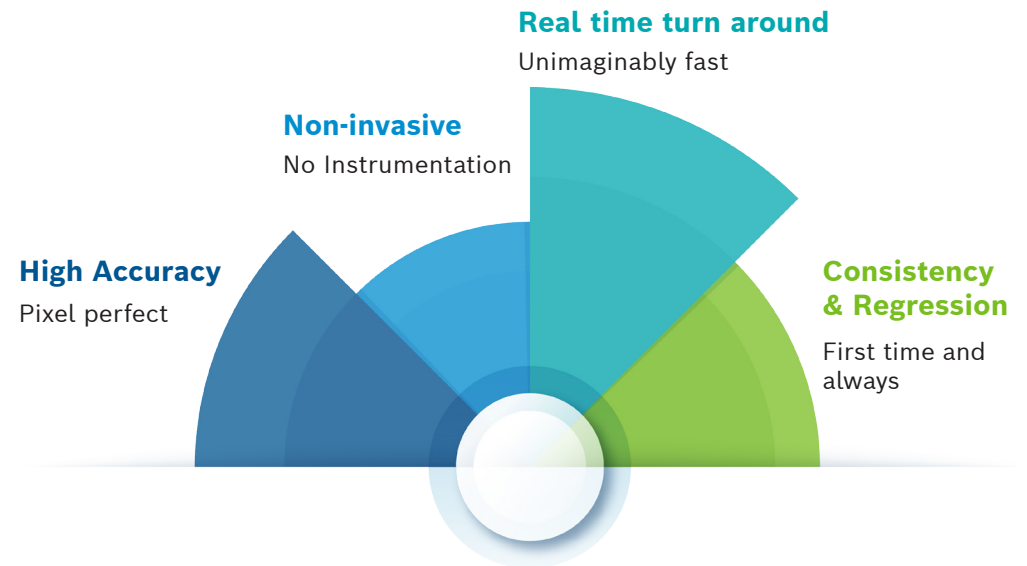
At Bosch we understand earning customer trust is directly in the hands of testing / validation, which is the last filter to end-consumers. Enabling customers to deliver quality software faster – "Quality at Speed" is the wand that we are unveiling through our Graphics Test Systems (GTS), a state-of-the-art HMI validation tool. Test automation cannot be realized without good tools. It is a critical part to maintain good velocity in a product design. We are ensuring testing solutions with capabilities catering to use cases panoramically across domains.

With a simple, user-friendly interface and seamless integration with existing test systems, GTS significantly improves returns on investment by reducing configuration time and eliminating the need for frequent test list updates, thus maintaining the accuracy of test results enabling unmatched regression possibilities.

The unique feature highlights of Bosch's GTS based HMI Test System enables wide use cases covering various domains like consumer electronics, Industry 4.0, Medical etc. complying to various standards expected from multiple domains.

GTS helps in making system testing phase most productive. They deliver for following goals

Real time turn around
Unimaginably fast

Non-invasive
No Instrumentation

High Accuracy
Pixel perfect

Consistency & Regression
First time and always

Framegrabber / Camera · RF · Audio Input · Camera / Framegrabber · IVI test Simulator module · Audio Output · Protocol · IC test Simulator module · HIL · Button Simulator module · Touch

▶ Most of the trending display systems use a HDMI interface for rendering. Our test system works seamlessly with such interfaces to capture images at the frame level running parallel to the actual rendering. In cases where systems use other interface methods like VGA, RGB, LVDS, Bosch provides adapter customizations to enable conversions without any compromise on timing.

▶ There is an industry necessity to test multiple display based products using the same test system and Bosch's HMI Test System based on GTS is scalable to test upto five display products at the same time

▶ Protocol testing solutions within the test framework is capable of testing multiple instances of network stacks within the software architecture of products. All bands of radio signals both near field and far away like Bluetooth, BLE, LoRA, Wifi, RF, GPS, and LAN & WAN are all testable with one shop solution. Interference and penetration level tests shall also be carried out seamlessly.

▶ IoT Products in a network behaving as Edge Device, Gateway, Router, and Cloud & Apps are all testable for make and break in communication, fault and recovery, dynamic & self-adapting networks.

▶ Touch and Button simulations are dedicated off-the-shelf modules, integratable to enable simulation in any kind of device from conventional hard buttons to smart devices using touch based gestures.

▶ The audio input output systems also can work with systems using varied technologies from single tone, multi tone, waves, and audio signal processing generators to natural voice inputs.

▶ Real time animations and 3D models rendered on display systems are perfectly verifiable against reference videos and models used to perform the rendering with absolutely no instrumentation in the code.

A few of the use cases are described below

Text Validation

GTS is capable of performing automated text and language translation validation in no time. Text validation with all language translations is verified with pixel perfect accuracy. It detects defects of all translations, color pallet validation and its size all in one shot for every string ID designed in the product.

Display & Touch Validation

GTS is capable of validating display outcome against recorded sequence of screen flow with event triggers. The events categorized under touch category shall also be tested for the common touch based interactions like click, flick, scroll and many more.

Luminance Detection

GTS is capable of detecting the intensity if light in a region of interest. Thus it can serve as an inevitable competitive test solution to validate various lighting conditions on displays, light sources, projection units and other consumer products. The system makes a relative comparison of illumination against a reference source in order to make the validation of the luminance factor. But generic capabilities like determining Day / Night mode etc are inherent in the system.

Color Identification

GTS is an intelligent color picker. It is capable of classification of colors and perform color matching to validate monitoring medical equipment. Such a principle is also adopted in cases of detecting road sign warnings and indications in automobiles.

Sequence & Alignment Detection

GTS is highly smart in detecting broken sequences in manufacturing industry and also in logical flow transitions in User interactive screens. It is self-adaptive to the triggers causing the flows and also can control the triggers using Robotic capabilities. Various Panels and controls used for interactions with machines could be validated in no time against requirements in the form of screen flows and event triggers
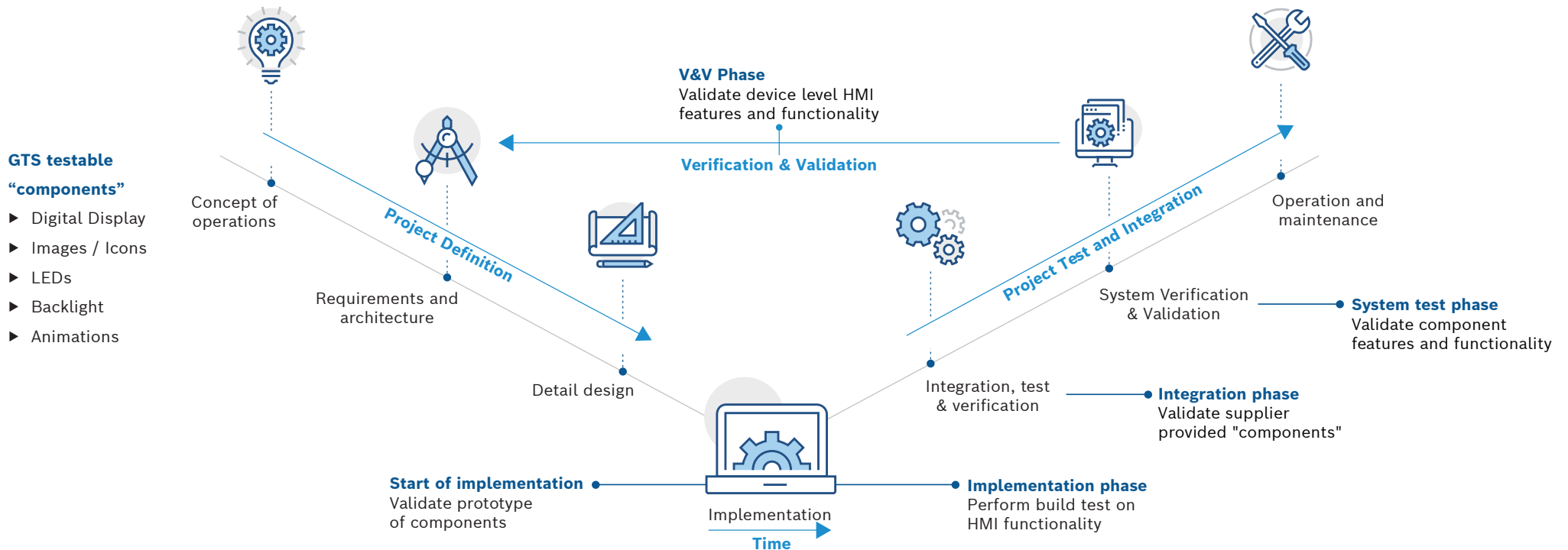
Sound / Voice Monitoring

GTS shall discriminate sound waves against recorded tones to validate alarms, tones, volume from appliances used across domains. It can discrimate right pitch and tone in voice samples.

Validate patient information and projection system

GTS is capable for adapting for testing Patient information system.

Graphics Test System
Bosch's answer to this puzzle

GTS testable "components"
- Digital Display
- Images / Icons
- LEDs
- Backlight
- Animations

Project Definition

Concept of operations

Requirements and architecture

Detail design

Implementation

Start of implementation
Validate prototype of components

Time

V&V Phase
Validate device level HMI features and functionality

Verification & Validation

Project Test and Integration

Operation and maintenance

System Verification & Validation

Integration, test & verification

System test phase
Validate component features and functionality

Integration phase
Validate supplier provided "components"

Implementation phase
Perform build test on HMI functionality

Hence the test solution from Bosch is powerful enough to propel solutions for multiple domains. There are innumerous customization possibilities in the test system solving critical challenges in many industrial, medical & automotive applications. It enables product designers to design, develop & relax for our test system to do the rest of the job. The GTS usage in a typical product development is explained below.

A typical example of integrating GTS into Sophisticated HIL test systems - Aerospace industry has test systems simulating various external conditions to test the Cockpit. GTS can be easily integrated into the existing test systems in order to make complete test fully automated which avoid users to provide manual feedback to verify content on the displays of the cockpit.

Similar methods hold good for medical equipment like Heart monitoring device which normally has an off the shelf UI device connected by the doctor to perform data collection from the controller system.

Flight Management systems device interface to display flight management data and other LRU aircraft function. MCDU (Multipurpose Control Display Unit) is high performance Liquid-Crystal Display that gives input to pilot and modify flight plans. Modern IFEs is much more capable to offer than traditional entertainment system – moving map, audio, video, games and live news, shopping and messaging via a capacitive touch screen. GTS can be integrated to the native test systems and validate designs.

Authors

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About Robert Bosch Engineering and Business Solutions Pvt. Ltd.

Robert Bosch Engineering and Business Solutions Private Limited is a 100% owned subsidiary of Robert Bosch GmbH, one of the world's leading lobal supplier of technology and services, offering end-to-end Engineering, IT and Business Solutions. With over 19,500 associates, it's the largest software development center of Bosch, outside Germany, indicating that it's the Technology Powerhouse of Bosch in India with a global footprint and presence in US, Europe and the Asia Pacific region.

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