# Graduation Project

<table>
<thead>
<tr>
<th>Assignment type</th>
<th>Master’s Thesis Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>TV Image Analysis and Enhancement on GPU (Dual Track)</td>
</tr>
<tr>
<td>Duration</td>
<td>Minimum: 9 months. Start Feb. 2015 or earlier</td>
</tr>
<tr>
<td>Company</td>
<td>Sigma Designs – Video Innovation Team Laan van Diepenvoorde 23, Waalre, The Netherlands</td>
</tr>
<tr>
<td>Contact person</td>
<td>Bahman Zafarifar Email: <a href="mailto:bahman_zafarifar@sigmadesigns.com">bahman_zafarifar@sigmadesigns.com</a> Tel: +31 88 0117739, Mob: +31 (0)623830875</td>
</tr>
</tbody>
</table>

## Company Background:

Sigma Designs is a leading force in the digital home entertainment market, delivering innovative semiconductor solutions for digital televisions and set-top boxes at the heart of today's digital home.

Video Innovation Team in Eindhoven is the European R&D center for innovative video processing applications for the next generation of our TV and set-top-box products.

## Assignment Introduction:

Modern digital televisions apply video signal analysis in order to determine the specific properties of each video signal, so as to apply appropriate type and extent of numerous video enhancement operations to the video at hand.

Video analysis operations include measuring the amount of image noise, sharpness and motion. Video restoration/enhancement operations include spatio-temporal noise and artefact reduction, sharpness and color enhancement, and motion-compensated frame-rate up-conversion.

The above operations are typically implemented on a System-On-Chip, containing a combination of (less flexible) dedicated hardware units that handle operations at pixel-level data, and a few (more flexible) microprocessors that handle the higher level inter-function control of image restoration/enhancement operations. The SW flexibility of microprocessors makes them suitable for implementing algorithmically complex, frame-level control operation. However, they are less suitable for high computational load required by pixel-level operations; a performance gap that is increasing as image formats grow. At the current state of the art, 1.4G pixel values (3840x2160x60x3) should be processed per second, allowing very few operations per pixel on an integrated microprocessor.

Modern TV SOCs also contain one or more Graphics Processing Units (GPUs), which offer both flexibility and high computational throughput. At the moment, GPUs are typically only used for rendering synthetic graphics, such as user interfaces and (Android) application outputs on the TV display. The potential of the integrated GPUs is currently not used for video analysis and enhancement.
Assignment Description:

The purpose of this assignment is to investigate the potential of using integrated GPUs for making advances in the current level of video analysis and enhancement.

The assignment may be carried out as a dual track project, each focusing on one of the following parts:

- **Algorithm development track**: Focusing on pixel-level feature extraction, and scene/event level classification.
  
  This may include developing pixel-level features for better determination of the type and level of image properties such as noise, sharpness, color, spatial alignment (gradient), and spatial structures repetition. At scene-level, multi-modal information from existing units, like motion vectors, may be included in the analysis. Examples for this level of analysis include detection of repetitive areas, or a temporally static region such as logo or subtitles. At event-level, multiple features are tracked and analyzed over longer periods of time, for detecting certain scenes or events (such as a football match) and individual video objects within the event of interest.

  Developed detectors may extend or replace currently existing ones, or they may enable new image enhancement operations for the objects of interest.

  We are especially interested in detecting/enhancing football matches.

- **GPU implementation track**: Implementing an existing or the newly developed image processing functions (features extraction, classification) on a GPU.

  A C language model of a generic pixel-level feature computation engine is already available. This model computes a series of color, frequency and orientation-related features at pixel-level, and averages these over a spatial neighborhood so as to come to a block-level feature vector for the neighborhood. This C model serves as an algorithmic starting point for the GPU implementation track.

Expected Outputs (Minimum Requirements and Extensions):

- **Algorithm development track**: The minimum requirement is to develop a detector for an object/event of interest, by fusing the existing pixel-level features, and possibly also other features available in the TV system (e.g. motion vectors or the existing noise/sharpness / frequency measurement outputs). The output would be in the form of local object classification maps.

  An extended goal is to investigate the potential of using the generated classification maps for improving image quality. A series of existing image reconstruction/enhancement applications can be used for this purpose; examples include texture synthesis, noise and artefact reduction, sharpness/color enhancement, and motion-compensated frame-rate up-conversion.

- **GPU implementation track**: The minimum requirement is to estimate the computational complexity of the functions of an existing feature computation engine for GPU implementation, and to actually implement a subset of these functions on the GPU.
Required Skills:

- **Algorithm development track:**
  - Knowledge of: Image processing / computer vision
  - Experienced in Matlab and C/C++ languages, and eager to set up own experiments

- **GPU implementation track:**
  - Experienced in programming GPUs, and knowledge of C/C++ languages
  - Capable of working independently with respect to GPU programming
  - Affinity with image processing is recommended