Image quality improvement of a-Si flat panel detectors: Enhanced temperature correction

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Introduction

High **MV-imaging** quality during the radiotherapy process is a major requirement for applications as for example image guided radiotherapy as well as patient security in general or verification tasks. Former works already improved the quality of images taken by so called **amorphous silicon (a-Si) flat panels** by implementing specific calibration and correction methods. These a-Si flat panel detectors are widely applied as electronic portal imaging devices on linear accelerators and are therefore exposed to high energetic radiation which damages especially the detector's electronic components and leads to a wide range of artefacts. Furthermore the detector itself has special behaviour and characteristics because of the damaged electronics that have to be considered. Particularly temperature has a high impact on the panel and is therefore subject to detailed investigations.

Problem definition

Former explorations demonstrate the tremendous **temperature dependence** of the flat panel. During a heating experiment where specific (electronic) parts of the detector were heated manually without additional MV-irradiation the effect of the increasing temperature resulted in significantly higher grey-level signals. Furthermore the test shows that depending on the heated component different temperature effects can be distinguished: There are pixel-specific effects (higher temperature at a pixel on the panel results in higher grey level signal) and electronic-specific effects (higher temperature at an electronic component results in higher grey level signal at the whole subpanel concerned). Especially for finding an exact and physically correct temperature correction this is a valuable knowledge.

As a result the information about the actual temperature state at the panel is a necessary foundation for all further correction approaches. So a special temperature surrogate – the so called **border offset** – is introduced and is now used in an improved **2nd level temperature correction** method.

Border Offset as a temperature surrogate

In order to monitor the panel temperature behaviour the border offset as a temperature surrogate is calculated regularly over the day. For finding a reliable temperature correlating value some things have to be considered. It is important that input pixels are not influenced by other effects as for example ghosting or bad pixels and that they are not in the focus of frequent clinical irradiation. As a result the border offset is determined by using three columns on the left and right side of the detector whereby only good pixels are considered. In detail the input pixels are sorted and the mean over the range between 5 and 10% is calculated. The resulting value is saved as border offset in a daily list which serves as information in temperature dependant application.

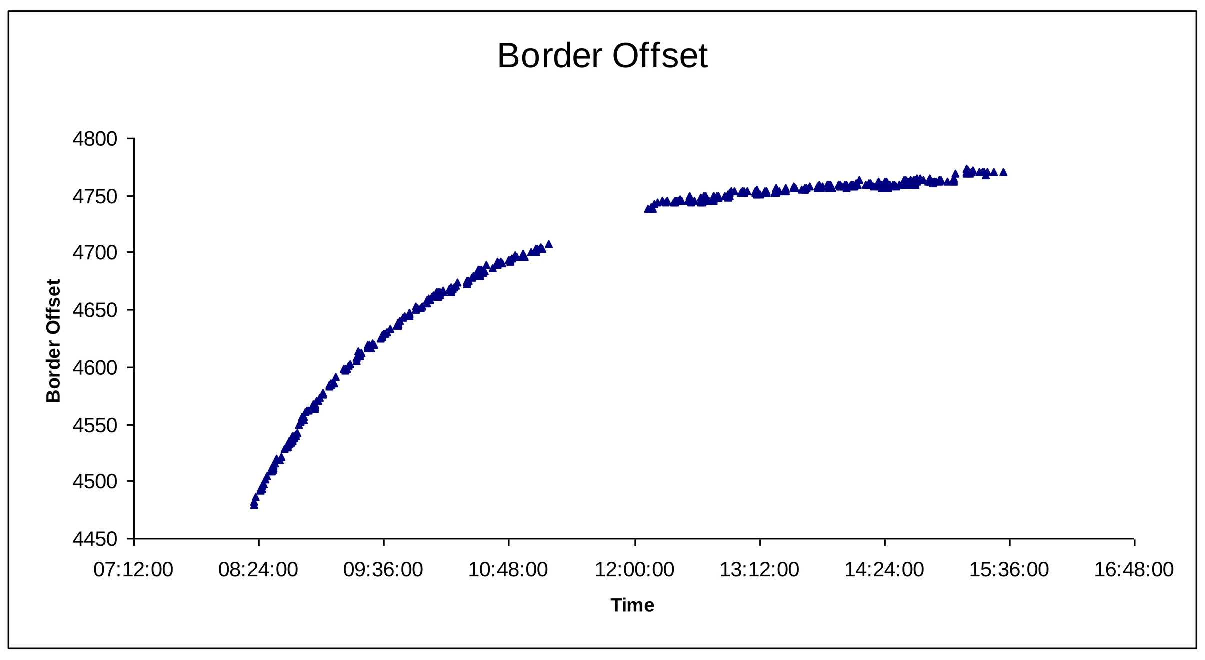

Figure 1: Example of an over the day increasing border offset

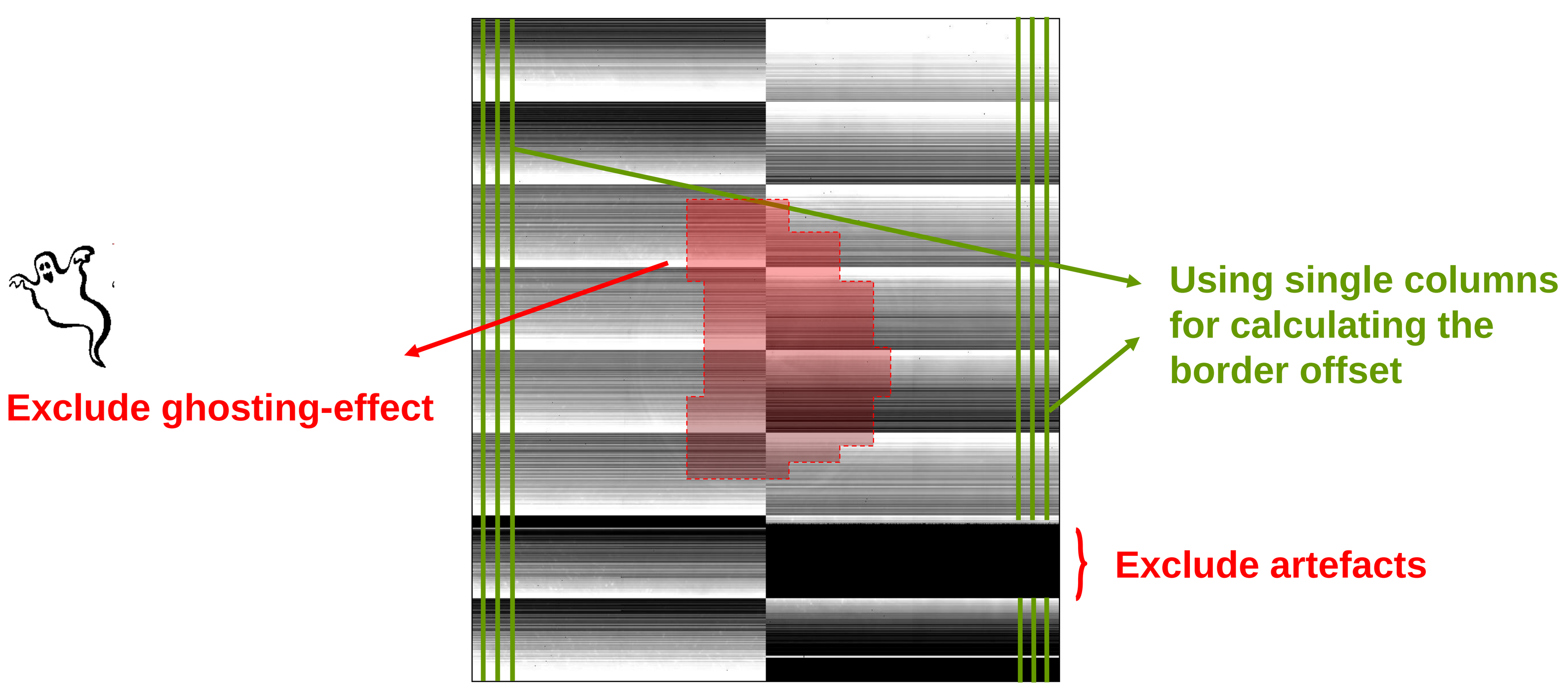

Figure 2: Border offset calculation

Improved temperature correction

The over the day growing border offset correlates with the increasing temperature at the detector. Because of the panel sensitivity to temperature changes this is an important effect. In a **1st order phenomenological temperature correction** the signal curve is adapted according to the current offset shift. For the mapping of the actual signal curve to the one at calibration time the only input needed is the offset and three predefined parameters that describe the bending and flexion behaviour.

In the case of very old and badly damaged panels the temperature dependent stripe artefacts get worse and despite of using the 1st level temperature correction method a certain residual may remain. This is the reason why a further improved **2nd level temperature correction** method was introduced.

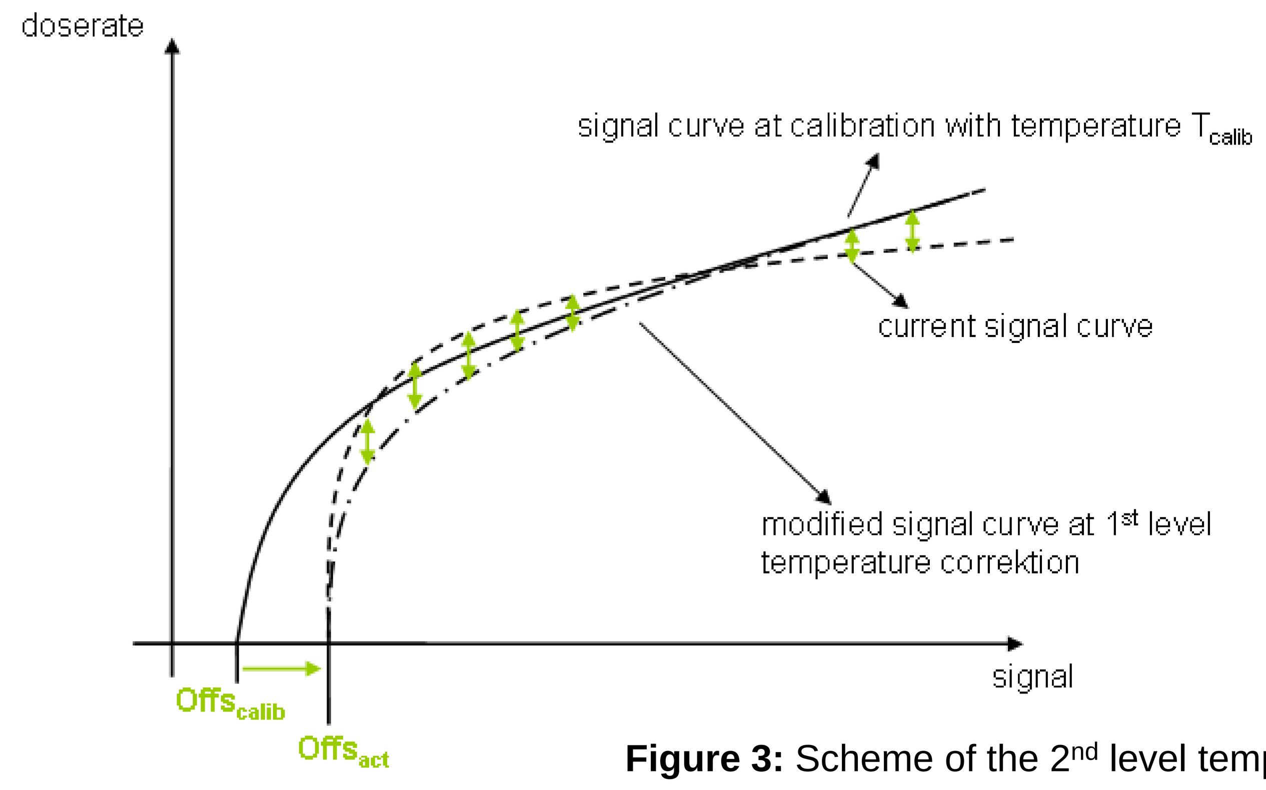

Figure 3: Scheme of the 2nd level temperature correction

During an additional calibration routine the **difference T-error** between the current measured signal curve and the one resulting after applying the 1st level correction is calculated. This has to be done for all doserate levels and each pixel separately. Afterwards the resulting values correlating with a particular border offset can be used for the correction task in order to get a high-quality image and furthermore the dosimetric information.

Figure 4: Wedge field after 2nd level temperature correction, taken by an over four-year-old panel

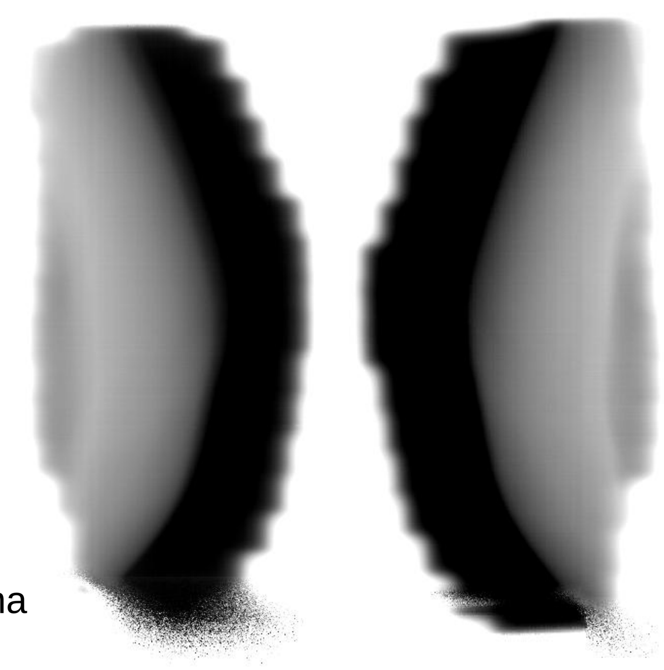

Figure 5: High-quality clinical images of a mamma

Because of the importance of an exact border offset at calibration time a range of points has to be considered within the **implementation**. The calibration field size is narrowed in order to protect the area where the border offset is calculated and not to falsify the value because of direct irradiation. In a further step the because of the smaller field size changing beam profile has to be considered whereby subpanel correction factors are calculated to flatten the image. Besides the border is extrapolated and special subpanel specific smoothing filters are used. The resulting temperature files are saved and serve as an important input for the temperature correction.

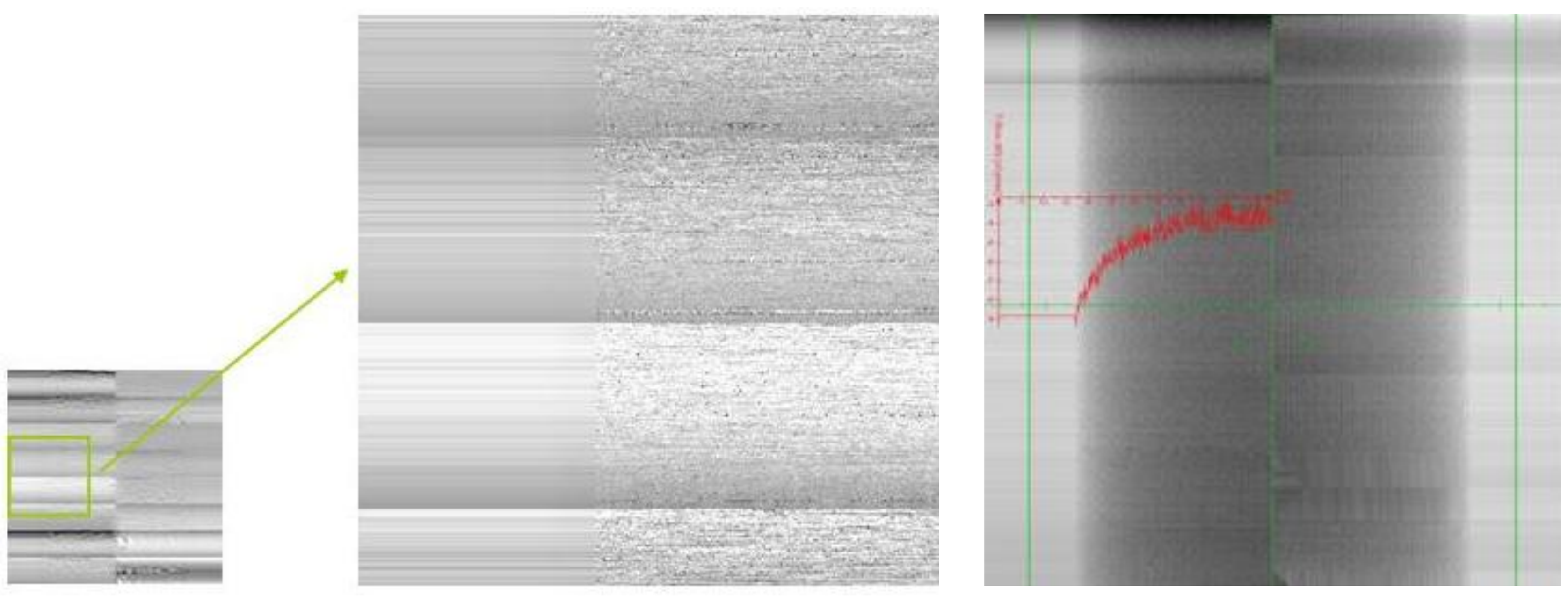

Figure 6: Extrapolation of the border (left) and compensation of the changed beam profile (right)