Breast cancer death is the second most common cancer death among women. Statistics show that an early cancer diagnosis is the key fact in reducing the breast cancer mortality rate. Imaging methods like X-ray mammography, mammosonography and breast MRI are used for the diagnosis of breast cancer. MRI is getting more important because it is insensitive to breast tissue density. Moreover, MRI acquires volumetric data, meaning it is three-dimensional (3D). We present an automatic breast lesion examination of Dynamic Contrast Enhanced MRI (DCE-MRI) data based on Fourier analysis. The results are presented in a novel and normalized visualization based on well established medical grading scheme, the Göttinger score.

### Problem Statement and Motivation

Breast cancer is the second most common cancer death among women. Statistics show that an early cancer diagnosis is the key fact in reducing the breast cancer mortality rate. Imaging methods like X-ray mammography, mammosonography and breast MRI are used for the diagnosis of breast cancer. MRI is getting more important because it is insensitive to breast tissue density. Moreover, MRI acquires volumetric data, meaning it is three-dimensional (3D). We present an automatic breast lesion examination of Dynamic Contrast Enhanced MRI (DCE-MRI) data based on Fourier analysis. The results are presented in a novel and normalized visualization based on well established medical grading scheme, the Göttinger score.

### Breast Cancer Classification: Göttinger Score

<table>
<thead>
<tr>
<th>Internal Enhancement</th>
<th>Morphologic Features</th>
<th>Kinetic Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>0: homogeneous (a)</td>
<td>0: smooth (a)</td>
<td>0: slow</td>
</tr>
<tr>
<td>1: heterogeneous (b)</td>
<td>1: blurred (d)</td>
<td>1: moderate</td>
</tr>
<tr>
<td>2: rim-enhanced (c)</td>
<td>1: irregular (e)</td>
<td>2: fast</td>
</tr>
<tr>
<td>Distribution of the contrast agent withing a lesion.</td>
<td>The transition of the lesion to the surrounding tissue.</td>
<td>The ISIs is the enhancement of a lesion in the early phase after contrast agent injection.</td>
</tr>
</tbody>
</table>

### Göttinger Score: Feature Computation

Mean diagonal elements of $J$ are used for classification. The amount of high frequency energy is analyzed.

Mean diagonal elements of $\mu(J)$ are used for classification. The amount of high frequency energy is analyzed.

Distribution of spectral energy is evaluated of the $\mu(J)$ and for each $J_i - \mu(J)$.

Inertia tensor $J$ is computed using the magnitudes of the Fourier transformed entire volume (f).

The volume is split into eight equally sized sub-volumes and inertia tensors $J_i$ are computed for each of the magnitudes of the Fourier transformed sub-volumes (g).

$\mu(J)$ is the mean tensor and is computed by averaging all inertia tensors $J_i$.

Relative enhancement (RE) is computed using pre-contrast and early post-contrast volume on per-voxel basis.

RE $< 0.5$: slow
RE $< 1.0$: moderate
RE $> 1.0$: fast

Relative enhancement is computed using early post-contrast and late post-contrast volume on per-voxel basis.

RE $> 0.1$: continuous
RE $> -0.1$: plateau
RE $< -0.1$: wash-out

### Malignancy Area Plot

All the features of the Göttinger score are combined in a normalized visualization called Malignancy Area Plot (MAP). In the center 0 points are assigned to the feature, the border represents the feature’s maximum value. The number in the middle represents the overall Göttinger score. High numbers indicate a high likelihood of a lesion being malignant and the color-coded area increases with the likelihood.