Isomorphe und homomorphe semiotische Grenzen und Ränder

1. Im Anschluß an die drei Vorgängerstudien zur topologischen Semiotik und ihrer zentralen Begriffe der semiotischen Nachbarschaft, linker (involvativer) und rechter (suppletiver) Ränder, von Grenzen und sog. Grenzrändern (vgl. Toth 2013a, b) soll im folgenden eine Darstellungsweise geboten werden, die es ermöglicht, für jedes Paar aus den 10 Peirce-Benseschen Zeichenklassen aufgrund der Nachbarschaften für $\Delta_{i,j} = \{1, 2, 3\}$ die isomorphen sowie homomorphen Grenzen, Ränder und Grenzränder auf einfache Weise festzustellen. Dieser "Service-Artikel" dient natürlich dazu, einerseits die bereits in den Vorgängerstudien formulierten und vorerst noch unbewiesenen Sätze der topologischen und algebraischen Semiotik ihren Beweisen entgegenzuführen und andererseits die Aufdeckung weiterer Sätze und Lemmata zu ermöglichen.

2.1. $\Delta_{i,j} = 1$

2.1.1.

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.2)) = (1.1, 1.2)$

$\mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset$

$\mathcal{R}_\rho(3.1, 2.1, 1.1) = \{(3.2), (3.3), (2.2), (2.3), (1.2), (1.3)\}$

$\mathcal{R}_\lambda(3.1, 2.1, 1.2) = (1.1)$

$\mathcal{R}_\rho(3.1, 2.1, 1.2) = \{(3.2), (3.3), (2.2), (2.3), (1.3)\}$

Grenzränder

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.1) = (1.2)$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.2) = (1.1)$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.2) = \emptyset$. 


2.1.2.
\[ G((3.1, 2.1, 1.2), (3.1, 2.1, 1.3)) = (1.2, 1.3) \]
\[ \mathcal{R}_\lambda(3.1, 2.1, 1.2) = (1.1) \]
\[ \mathcal{R}_\rho(3.1, 2.1, 1.2) = \{(3.2), (3.3), (2.2), (2.3), (1.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.1, 1.3) = \{(1.1), (1.2)\} \]
\[ \mathcal{R}_\rho(3.1, 2.1, 1.3) = \{(3.2), (3.3), (2.2), (2.3)\} \]

Grenzräder
\[ G((3.1, 2.1, 1.2), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.2) = \emptyset \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.2) = (1.3) \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.3) = (1.2) \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.3) = \emptyset. \]

2.1.3.
\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.2)) = ((2.1, 2.2), (1.2, 1.3)) \]
\[ \mathcal{R}_\lambda(3.1, 2.1, 1.3) = \{(1.1), (1.2)\} \]
\[ \mathcal{R}_\rho(3.1, 2.1, 1.3) = \{(3.2), (3.3), (2.2), (2.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \{(1.1), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\} \]

Grenzräder
\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.3) = (1.2) \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.3) = (2.2) \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = (2.1) \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = (1.3). \]
2.1.4. 
\[ G((3.1, 2.2, 1.2), (3.1, 2.2, 1.3)) = (2.2, (1.2, 1.3)) \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \{(1.1), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]
Grenzräume
\[ G((3.1, 2.2, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \emptyset \]
\[ G((3.1, 2.2, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = (1.3) \]
\[ G((3.1, 2.2, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = (1.2) \]
\[ G((3.1, 2.2, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = \emptyset. \]

2.1.5.
\[ G((3.1, 2.2, 1.3), (3.1, 2.3, 1.3)) = ((2.2, 2.3), 1.3) \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\} \]
\[ \mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\} \]
Grenzräume
\[ G((3.1, 2.2, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \emptyset \]
\[ G((3.1, 2.2, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = (2.3) \]
\[ G((3.1, 2.2, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = (2.2, 2.3) \]
\[ G((3.1, 2.2, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = \emptyset. \]
2.1.6.
\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.2)) = ((3.1, 3.2), (2.2, 2.3), (1.2, 1.3)) \]
\[ \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\} \]
\[ \mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\} \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\} \]

Grenzränder
\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = (2.2, 2.3, 1.2) \]
\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = (3.2) \]
\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = (3.1) \]
\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = (2.3, 1.3). \]

2.1.7.
\[ G((3.2, 2.2, 1.2), (3.2, 2.2, 1.3)) = (1.2, 1.3) \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\} \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.3) = \{(3.3), (2.3)\} \]

Grenzränder
\[ G((3.2, 2.2, 1.2), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \emptyset \]
\[ G((3.2, 2.2, 1.2), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = (1.3) \]
\[ G((3.2, 2.2, 1.2), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.3) = (1.2) \]
\[ G((3.2, 2.2, 1.2), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.3) = \emptyset. \]
2.1.8.
\[ G((3.2, 2.2, 1.3), (3.2, 2.3, 1.3)) = (2.2, 2.3) \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.3) = \{(3.3), (2.3)\} \]
\[ \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3) \]
Grenzränder
\[ G((3.2, 2.2, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \emptyset \]
\[ G((3.2, 2.2, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.3) = (2.3) \]
\[ G((3.2, 2.2, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.3, 1.3) = (2.2) \]
\[ G((3.2, 2.2, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = \emptyset. \]

2.1.9.
\[ G((3.2, 2.3, 1.3), (3.3, 2.3, 1.3)) = (3.2, 3.3) \]
\[ \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3) \]
\[ \mathcal{R}_\lambda(3.3, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1), (3.2)\} \]
\[ \mathcal{R}_\rho(3.3, 2.3, 1.3) = \emptyset \]
Grenzränder
\[ G((3.2, 2.3, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \emptyset \]
\[ G((3.2, 2.3, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3) \]
\[ G((3.2, 2.3, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.3, 2.3, 1.3) = (3.2) \]
\[ G((3.2, 2.3, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.3, 2.3, 1.3) = \emptyset. \]
2.2. $\Delta_{ij} = 2$

2.2.1.

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.3)) = (1.1, 1.3)$

$\mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset$

$\mathcal{R}_\rho(3.1, 2.1, 1.1) = \{(3.2), (3.3), (2.2), (2.3), (1.2), (1.3)\}$

$\mathcal{R}_\lambda(3.1, 2.1, 1.3) = \{(1.1), (1.2)\}$

$\mathcal{R}_\rho(3.1, 2.1, 1.3) = \{(3.2), (3.3), (2.2), (2.3)\}$

Grenzränder

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.1) = (1.3)$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.3) = (1.1)$

$G((3.1, 2.1, 1.1), (3.1, 2.1, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.3) = \emptyset.$

2.2.2.

$G((3.1, 2.1, 1.2), (3.1, 2.2, 1.2)) = (2.1, 2.2)$

$\mathcal{R}_\lambda(3.1, 2.1, 1.2) = (1.1)$

$\mathcal{R}_\rho(3.1, 2.1, 1.2) = \{(3.2), (3.3), (2.2), (2.3), (1.3)\}$

$\mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\}$

Grenzränder

$G((3.1, 2.1, 1.2), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.2) = \emptyset$

$G((3.1, 2.1, 1.2), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.2) = (2.2)$

$G((3.1, 2.1, 1.2), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = (2.1)$

$G((3.1, 2.1, 1.2), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = \emptyset.$
2.2.3.

\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.3)) = (2.1, 2.2) \]

\[ \mathcal{R}_\lambda(3.1, 2.1, 1.3) = \{(1.1), (1.2)\} \]

\[ \mathcal{R}_\rho(3.1, 2.1, 1.3) = \{(3.2), (3.3), (2.2), (2.3)\} \]

\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]

\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]

Grenzränder

\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.3) = \emptyset \]

\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.3) = (2.2) \]

\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = (2.1) \]

\[ G((3.1, 2.1, 1.3), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = \emptyset. \]

2.2.4.

\[ G((3.1, 2.2, 1.2), (3.1, 2.3, 1.3)) = ((2.2, 2.3), (1.2, 1.3)) \]

\[ \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \{(1.1), (2.1)\} \]

\[ \mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\} \]

\[ \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\} \]

\[ \mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\} \]

Grenzränder

\[ G((3.1, 2.2, 1.2), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \emptyset \]

\[ G((3.1, 2.2, 1.2), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = (1.3, 2.3) \]

\[ G((3.1, 2.2, 1.2), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = (1.2, 2.2) \]

\[ G((3.1, 2.2, 1.2), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = \emptyset. \]
2.2.5.

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.2)) = ((3.1, 3.2), (1.2, 1.3)) \]

\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]

\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]

\[ \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\} \]

Grenzränder

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = (1.2) \]

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = (3.2) \]

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = (3.1) \]

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = (1.3) \]

2.2.6.

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) = ((3.1, 3.2), (2.2, 2.3)) \]

\[ \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\} \]

\[ \mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\} \]

\[ \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.3, 1.3) = \{(3.3), (2.3)\} \]

Grenzränder

\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = (2.2) \]

\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = (3.2) \]

\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.3) = (3.1) \]

\[ G((3.1, 2.3, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.3) = (2.3) \]
2.2.7.

\[ G((3.2, 2.2, 1.2), (3.2, 2.3, 1.3)) = ((2.2, 2.3), (1.2, 1.3)) \]

\[ \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\} \]

\[ \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3) \]

Grenzränder

\[ G((3.2, 2.2, 1.2), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \emptyset \]

\[ G((3.2, 2.2, 1.2), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = (2.3, 1.3) \]

\[ G((3.2, 2.2, 1.2), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.3, 1.3) = (2.2, 1.2) \]

\[ G((3.2, 2.2, 1.2), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = \emptyset. \]

2.2.8.

\[ G((3.2, 2.2, 1.3), (3.3, 2.3, 1.3)) = ((3.2, 3.3), (2.2, 2.3)) \]

\[ \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.2, 1.3) = \{(3.3), (2.3)\} \]

\[ \mathcal{R}_\lambda(3.3, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1), (3.2)\} \]

Grenzränder

\[ G((3.2, 2.2, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \emptyset \]

\[ G((3.2, 2.2, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.3) = (2.3, 3.3) \]

\[ G((3.2, 2.2, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.3, 2.3, 1.3) = (2.2, 3.2) \]

\[ G((3.2, 2.2, 1.3), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.3, 2.3, 1.3) = \emptyset. \]
2.2.9.

\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.1)) = ((3.1, 3.2), (2.1, 2.3), (1.1, 1.3)) \]

\[ \mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\} \]

\[ \mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3) \]

\[ \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset \]

\[ \mathcal{R}_\rho(3.1, 2.1, 1.1) = \{(3.2), (3.3), (2.2), (2.3), (1.2), (1.3)\} \]

Grenzräume

\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.1)) \cap \mathcal{R}_\lambda(3.2, 2.3, 1.3) = (1.1, 2.1, 3.1) \]

\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.1)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = \emptyset \]

\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.1)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset \]

\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.1)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = \emptyset. \]

2.3. \( \Delta_{ij} = 3 \)

2.3.1.

\[ G((3.1, 2.1, 1.1), (3.1, 2.2, 1.2)) = ((2.1, 2.2), (1.1, 1.2)) \]

\[ \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset \]

\[ \mathcal{R}_\rho(3.1, 2.1, 1.1) = \{(3.2), (3.3), (2.2), (2.3), (1.2), (1.3)\} \]

\[ \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \{(1.1), (2.1)\} \]

\[ \mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\} \]

Grenzräume

\[ G((3.1, 2.1, 1.1), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.1) = \emptyset \]

\[ G((3.1, 2.1, 1.1), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.1) = (1.2, 2.2) \]

\[ G((3.1, 2.1, 1.1), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = (1.1, 2.1) \]
\[ G((3.1, 2.1, 1.1), (3.1, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = \emptyset. \]

2.3.2.
\[ G((3.1, 2.1, 1.2), (3.1, 2.2, 1.3)) = ((2.1, 2.2), (1.2, 1.3)) \]
\[ \mathcal{R}_\lambda(3.1, 2.1, 1.2) = (1.1) \]
\[ \mathcal{R}_\rho(3.1, 2.1, 1.2) = \{(3.2), (3.3), (2.2), (2.3), (1.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]
\[ \text{Grenzränder} \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.2) \equiv \emptyset \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.2) = (1.3, 2.2) \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = (1.2, 2.1) \]
\[ G((3.1, 2.1, 1.2), (3.1, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = \emptyset. \]

2.3.3.
\[ G((3.1, 2.1, 1.3), (3.1, 2.3, 1.3)) = (2.1, 2.3) \]
\[ \mathcal{R}_\lambda(3.1, 2.1, 1.3) = \{(1.1), (1.2)\} \]
\[ \mathcal{R}_\rho(3.1, 2.1, 1.3) = \{(3.2), (3.3), (2.2), (2.3)\} \]
\[ \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\} \]
\[ \mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\} \]
\[ \text{Grenzränder} \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.1, 1.3) \equiv \emptyset \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.3) = (2.3) \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = (2.1) \]
\[ G((3.1, 2.1, 1.3), (3.1, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = \emptyset. \]

2.3.4.
\[ G((3.1, 2.2, 1.2), (3.2, 2.2, 1.2)) = (3.1, 3.2) \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \{(1.1), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.2) = \{(3.2), (3.3), (2.3), (1.3)\} \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\} \]

Grenzränder

\[ G((3.1, 2.2, 1.2), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.2) = \emptyset \]
\[ G((3.1, 2.2, 1.2), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.2) = (3.2) \]
\[ G((3.1, 2.2, 1.2), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = (3.1) \]
\[ G((3.1, 2.2, 1.2), (3.2, 2.2, 1.2)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = \emptyset. \]

2.3.5.
\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) = (3.1, 3.2) \]
\[ \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \{(1.1), (1.2), (2.1)\} \]
\[ \mathcal{R}_\rho(3.1, 2.2, 1.3) = \{(3.2), (3.3), (2.3)\} \]
\[ \mathcal{R}_\lambda(3.2, 2.2, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]
\[ \mathcal{R}_\rho(3.2, 2.2, 1.3) = \{(3.3), (2.3)\} \]

Grenzränder

\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.2, 1.3) = \emptyset \]
\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.2, 1.3) = (3.2) \]
\[ G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.3) = (3.1) \]
G((3.1, 2.2, 1.3), (3.2, 2.2, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.3) = \emptyset.

2.3.6.
G((3.1, 2.3, 1.3), (3.2, 2.3, 1.3)) = (3.1, 3.2)
\mathcal{R}_\lambda(3.1, 2.3, 1.3) = \{(1.1), (1.2), (2.2), (2.3)\}
\mathcal{R}_\rho(3.1, 2.3, 1.3) = \{(3.2), (3.3)\}
\mathcal{R}_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\}
\mathcal{R}_\rho(3.2, 2.3, 1.3) = (3.3)

Grenzränder
G((3.1, 2.3, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.1, 2.3, 1.3) = \emptyset
G((3.1, 2.3, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.1, 2.3, 1.3) = (3.2)
G((3.1, 2.3, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.3, 1.3) = (3.1)
G((3.1, 2.3, 1.3), (3.2, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.3, 1.3) = \emptyset.

2.3.7.
G((3.2, 2.2, 1.2), (3.3, 2.3, 1.3)) = ((3.2, 3.3), (2.2, 2.3), (1.2, 1.3))
\mathcal{R}_\lambda(3.2, 2.2, 1.2) = \{(1.1), (2.1), (3.1)\}
\mathcal{R}_\rho(3.2, 2.2, 1.2) = \{(3.3), (2.3), (1.3)\}
\mathcal{R}_\lambda(3.3, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1), (3.2)\}
\mathcal{R}_\rho(3.3, 2.3, 1.3) = \emptyset

Grenzränder
G((3.2, 2.2, 1.2), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.2, 2.2, 1.2) = \emptyset
G((3.2, 2.2, 1.2), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\rho(3.2, 2.2, 1.2) = (1.3, 2.3, 3.3)
G((3.2, 2.2, 1.2), (3.3, 2.3, 1.3)) \cap \mathcal{R}_\lambda(3.3, 2.3, 1.3) = (1.2, 2.2, 3.2)
\[ G((3.2, 2.2, 1.2), (3.3, 2.3, 1.3)) \cap R_\rho(3.3, 2.3, 1.3) = \emptyset. \]

2.3.8.
\[ G((3.2, 2.2, 1.3), (3.1, 2.1, 1.1)) = ((3.1, 3.2), (2.1, 2.2), (1.1, 1.3)) \]
\[ R_\lambda(3.2, 2.2, 1.3) = \{(1.1), (1.2), (2.1), (3.1)\} \]
\[ R_\rho(3.2, 2.2, 1.3) = \{(3.3), (2.3)\} \]
\[ R_\lambda(3.1, 2.1, 1.1) = \emptyset \]
\[ R_\rho(3.1, 2.1, 1.1) = \{(3.2), (3.3), (2.2), (2.3), (1.2), (1.3)\} \]

Grenzränder
\[ G((3.2, 2.2, 1.3), (3.1, 2.1, 1.1)) \cap R_\lambda(3.2, 2.2, 1.3) = (1.1, 2.1, 3.1) \]
\[ G((3.2, 2.2, 1.3), (3.1, 2.1, 1.1)) \cap R_\rho(3.2, 2.2, 1.3) = \emptyset \]
\[ G((3.2, 2.2, 1.3), (3.1, 2.1, 1.1)) \cap R_\lambda(3.1, 2.1, 1.1) = \emptyset \]
\[ G((3.2, 2.2, 1.3), (3.1, 2.1, 1.1)) \cap R_\rho(3.1, 2.1, 1.1) = (1.3, 2.2, 3.2). \]

2.3.9.
\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.2)) = ((3.1, 3.2), (2.1, 2.3), (1.2, 1.3)) \]
\[ R_\lambda(3.2, 2.3, 1.3) = \{(1.1), (1.2), (2.1), (2.2), (3.1)\} \]
\[ R_\rho(3.2, 2.3, 1.3) = (3.3) \]
\[ R_\lambda(3.1, 2.1, 1.2) = (1.1) \]
\[ R_\rho(3.1, 2.1, 1.2) = \{(3.2), (3.3), (2.2), (2.3), (1.3)\} \]

Grenzränder
\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.2)) \cap R_\lambda(3.2, 2.3, 1.3) = (1.2, 2.1, 3.1) \]
\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.2)) \cap R_\rho(3.2, 2.3, 1.3) = \emptyset \]
\[ G((3.2, 2.3, 1.3), (3.1, 2.1, 1.2)) \cap R_\lambda(3.1, 2.1, 1.2) = \emptyset \]
G((3.2, 2.3, 1.3), (3.1, 2.1, 1.2)) \cap \mathcal{R}_\rho(3.1, 2.1, 1.2) = (1.3, 2.3, 3.2).

Literatur


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