# A RELATION DEFINTIONS

$$\mathit{Implication} \coloneqq \{(x,y) \in V \times V \mid l(x) \models l(y)\} \tag{1}$$

$$\mathit{Alternative} \coloneqq \{(x,y) \in V \times V \mid l(x) \models \neg l(y)\} \tag{2}$$

$$\begin{aligned}\mathit{Independent} \coloneqq \{(x,y) \in V \times V \mid\ & \mathit{isSatisfiable}(l(x) \wedge l(y)),\\ & \mathit{isSatisfiable}(l(x) \wedge \neg l(y)),\\ & \mathit{isSatisfiable}(\neg l(x) \wedge l(y))\}\end{aligned}$$

# B RELATION COMPLETENESS PROOF & TABLE

Proof. Formally, "every pair of feature mapping nodes is either in an *Independent*, *Implication*, or *Alternative* relation" translates to the conjunction of the following SAT calls:

$$\begin{aligned}&(SAT(l(x) \wedge l(y)) \wedge SAT(l(x) \wedge \neg l(y)) \wedge SAT(\neg l(x) \wedge l(y))\\ &\vee \neg SAT(\neg(\neg l(x) \vee l(y))) \vee \neg SAT(\neg(\neg l(y) \vee l(x)))\\ &\vee \neg SAT(\neg(\neg l(x) \vee \neg l(y)))\end{aligned}$$

We apply DeMorgan's law twice:

$$\begin{aligned}&= (SAT(l(x) \wedge l(y)) \wedge SAT(l(x) \wedge \neg l(y)) \wedge SAT(\neg l(x) \wedge l(y))\\ &\quad \vee \neg SAT((l(x) \wedge \neg l(y))) \vee \neg SAT(l(y) \wedge \neg l(x)))\\ &\quad \vee \neg SAT((l(x) \wedge l(y)))\\ &= \quad (SAT(l(x) \wedge l(y)) \wedge SAT(l(x) \wedge \neg l(y)) \wedge SAT(\neg l(x) \wedge l(y))\\ &\quad \vee\ \neg(SAT(l(x) \wedge l(y)) \wedge SAT(l(x) \wedge \neg l(y)) \wedge SAT(\neg l(x) \wedge l(y))\\ &= \mathit{true}\end{aligned}$$

Therefore, every pair of feature mappings is guaranteed to be in at least one of the relations *Independent*, *Implication*, and *Alternative*.

**Textual Proof.** We conduct our textual proof by taking a closer look at the check for the Independent relation:

$$\begin{aligned}&SAT(l(x) \wedge l(y))\\ &\wedge SAT(l(x) \wedge \neg l(y))\\ &\wedge SAT(\neg l(x) \wedge l(y))\end{aligned}$$

If this formula evaluates to *True*, the two nodes $x$ and $y$ are in the *Independent* relation. The two nodes can not be in the *Alternative* relation since $SAT(l(x) \wedge l(y)) = \mathit{True}$. Additionally, the two nodes can not be in the *Implication* relation, because $SAT(l(x) \wedge \neg l(y)) = SAT(\neg l(x) \wedge l(y)) = \mathit{True}$, meaning there are variable assignments that contradict either $l(x)$ modelling $l(y)$ or $l(y)$ modelling $l(x)$

Now, there are several ways the check for *Independent* can evaluate to *False*, namely each or multiple of the SAT calls fail: If $SAT(l(x) \wedge l(y))$ succeeds and one or both of the other SAT calls fail, the respective nodes are in an *Implication* relation with each other. Note that the nodes can not be in the *Alternative* relation, since $SAT(l(x) \wedge l(y))$ succeeds, i.e., there are variants in which both $x$ and $y$ are present. If $SAT(l(x) \wedge l(y))$ fails but the two other SAT calls succeed, there are variable assignments that fulfil each formula but none that fulfil both, therefore leaving us with the *Alternative* relation between the two nodes. For $SAT(l(x) \wedge l(y))$ failing and exactly one of the two other SAT calls succeeding, one of the respective formulas has to be *False*, giving the node an *Implication* edge, which is analogous to the empty set being a subset of every other set. If all three SAT calls fail, both $l(x)$ and $l(y)$ must be *False*, which would fulfil both *Implication* and *Alternative*. A complete table with all cases any of the SAT calls can fail or succeed for can be found in Table 4. Since we covered every potential case the check for *Independent* can succeed or fail and since for every case at least one relation applies, every pair of feature mapping nodes has a relation from the set {*Implication*,*Alternative*,*Independent*}. □

# C COMMUTATIVITY OF REDUCE AND PROJECT

Lemma C.1. *For any edge-typed variation diff $D$ and any time $t \in \{$before, after$\}$ reduction and projection commute:*

$$\mathit{reduce}_{VT}(\mathit{project}_{ET}(D,t)) = \mathit{project}(\mathit{reduce}_{VD}(D),t).$$

Proof Sketch.

$$\begin{aligned}&\mathit{reduce}_{VT}(\ \mathit{project}_{ET}((V,E,r,\tau,l,\Delta,\pi),t)\\ &= \mathit{reduce}_{VT}(\ (\{v \in V \mid \mathit{exists}(t,\Delta(v))\},\\ &\qquad \{e \in E \mid \pi(e) = \mathit{Nesting} \wedge \mathit{exists}(t,\Delta(e))\}\\ &\qquad \cup \{(x,y) \in E \mid \pi(e) \neq \mathit{Nesting}\\ &\qquad \wedge \mathit{exists}(t,\Delta(x)) \wedge \mathit{exists}(t,\Delta(y))\},\\ &\qquad r,\tau,l,\pi))\\ &= \qquad (\{v \in V \mid \mathit{exists}(t,\Delta(v))\},\\ &\qquad \{e \in E \mid \pi(e) = \mathit{Nesting} \wedge \mathit{exists}(t,\Delta(e))\}\\ &\qquad r,\tau,l))\\ &= \mathit{project}(\quad (V,\\ &\qquad \{e \in E \mid \pi(e) = \mathit{Nesting}\},\\ &\qquad r,\tau,l,\Delta)),t)\\ &= \qquad \mathit{project}(\mathit{reduce}_{VD}((V,E,r,\tau,l,\Delta,\pi)),t)\end{aligned}$$

□

| Evaluation of the SAT calls | | | |
|---|---|---|---|
| $SAT(l(x) \wedge l(y))$ | $SAT(l(x) \wedge \neg l(y))$ | $SAT(\neg l(x) \wedge l(y))$ | Relation type |
| 1 | 1 | 1 | *Independent* |
| 1 | 1 | 0 | *Implication* with $l(y) \models l(x)$ |
| 1 | 0 | 1 | *Implication* with $l(x) \models l(y)$ |
| 1 | 0 | 0 | *Implication* with $l(x)$ equivalent to $l(y)$ |
| 0 | 1 | 1 | *Alternative* |
| 0 | 1 | 0 | *Implication* where $l(y)$ is *False* |
| 0 | 0 | 1 | *Implication* where $l(x) isFalse$ |
| 0 | 0 | 0 | *Implication/Alternative* where $l(x)$ and $l(y)$ are *False*) |

**Table 4: All potential cases the *Independent* SAT call can succeed and fail for**