

Supplementary Material

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1 PROPERTY SPECIFICATIONS IN ALLOY

The Alloy specifications for the 11 properties studied in this paper are given below.

// set and relation declaration

```
sig S {
  r: set S
}
```

// predicates

```
pred Antisymmetric() {
  all s, t: S | s->t in r and t->s in r implies s = t
}
```

```
pred Connex() {
  all s, t: S | s->t in r or t->s in r
}
```

```
pred Equivalence() {
  Reflexive[]
  Symmetric[]
  Transitive[]
}
```

```
pred Irreflexive() {
  all s, t: S | s->t in r implies s != t
}
```

```
pred NonStrictOrder() {
  Reflexive[]
  Antisymmetric[]
  Transitive[]
}
```

```
pred PartialOrder() {
  Antisymmetric[]
  Transitive[]
}
```

```
pred PreOrder() {
```

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```
Reflexive[]
Transitive[]
}
```

```
pred Reflexive() {
  all s: S | s->s in r
}
```

```
pred StrictOrder() {
  Irreflexive[]
  Transitive[]
}
```

```
pred Symmetric() {
  all s, t: S | s->t in r implies t->s in r
}
```

```
pred TotalOrder() {
  PartialOrder[]
  Connex[]
}
```

```
pred Transitive() {
  all s, t, u: S | s->t in r and t->u in r implies s->u in r
}
```

Table 1: Training Datasets for graph properties. For each property, the number of nodes in the graph (*Scope*), the number of graphs satisfying the property (*Positive*) and the number of graphs violating the property (*Negative*) are shown.

Property	Scope	Positive	Negative
Antisymmetric	5	3.78E+06	2.98E+07
	4	23328	42208
Connex	5	1.18E+05	3.34E+07
	4	1458	64078
Equivalence	10	2.32E+05	1.27E+30
Irreflexive	5	2.10E+06	3.15E+07
	4	8192	57344
NonStrictOrder	6	2.60E+05	6.87E+10
	4	438	65098
PartialOrder	5	2.71E+05	3.33E+07
	4	7008	58528
PreOrder	6	4.19E+05	6.87E+10
	4	710	64826
Reflexive	5	2.10E+06	3.15E+07
	4	8192	57344
StrictOrder	6	2.60E+05	6.87E+10
	4	438	65098
TotalOrder	9	7.25E+05	2.42E+24
Transitive	5	3.09E+05	3.32E+07
	4	7988	57548

Table 2: Model Counts (MCML and *QuantifyML*) are tabulated for each of the four cases considered (i.e., true positive (TP), false negative (FN), false positive (FP), and true negative (TN). Difference column shows differences between model counts calculated by MCML and *QuantifyML*. Model Counter is ApproxMC.

Property	True Positives			False Negatives			False Positives			True Negatives		
	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff
Antisymmetric	2.00E+06	1.90E+06	4.9	336	336	0.0	1.31E+04	1.23E+04	6.2	3.15E+07	3.20E+07	-1.5
Connex	6.45E+04	6.45E+04	0.0	98	98	0.0	2.21E+05	2.17E+05	1.8	3.36E+07	3.36E+07	0.0
Equivalence	1.21E+05	1.27E+05	-5.1	0	0	0.0	6.96E+26	6.96E+26	0.0	1.27E+30	1.27E+30	0.0
Irreflexive	1.05E+06	1.05E+06	0.0	0	0	0.0	0	0	0.0	3.25E+07	3.25E+07	0.0
NonStrictOrder	1.29E+05	1.25E+05	3.2	66	66	0.0	1.17E+08	1.05E+08	10.4	6.87E+10	6.87E+10	0.0
PartialOrder	1.45E+05	1.39E+05	4.2	114	116	-1.8	4.59E+05	4.10E+05	10.8	3.30E+07	3.36E+07	-1.7
PreOrder	2.29E+05	2.29E+05	0.0	80	74	7.5	1.93E+08	1.89E+08	2.2	6.87E+10	6.87E+10	0.0
Reflexive	1.05E+06	1.05E+06	0.0	0	0	0.0	0	0	0.0	3.25E+07	3.25E+07	0.0
StrictOrder	1.35E+05	1.43E+05	-6.1	31	31	0.0	1.43E+08	1.43E+08	0.3	6.87E+10	6.87E+10	0.0
TotalOrder	4.01E+05	3.44E+05	14.3	0	2.01E+08	-	7.01E+20	7.38E+20	-5.3	2.42E+24	2.42E+24	0.0
Transitive	1.52E+05	1.72E+05	-13.5	1504	1344	10.6	8.03E+05	7.70E+05	4.1	3.25E+07	3.30E+07	-1.6

Table 3: Model Counts (MCML and *QuantifyML*) are tabulated for each of the four cases considered (i.e., true positive (TP), false negative (FN), false positive (FP), and true negative (TN). Difference column shows differences between model counts calculated by MCML and *QuantifyML*. Model Counter is projMC. "-" indicates a time-out of 5000 seconds

Property	True Positives			False Negatives			False Positives			True Negatives		
	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff	MCML	QuantifyML	Diff
Antisymmetric	1.89E+06	1.89E+06	0.0	332	332	0.0	1.18E+04	1.18E+04	0.0	3.17E+07	3.17E+07	0.0
Connex	5.90E+04	5.90E+04	0.0	96	96	0.0	2.21E+05	2.21E+05	0.0	3.33E+07	3.33E+07	0.0
Equivalence	1.16E+05	1.16E+05	0.0	0	0	0.0	-	-	-	-	-	-
Irreflexive	1.05E+06	1.05E+06	0.0	0	0	0.0	0	0	0.0	3.25E+07	3.25E+07	0.0
NonStrictOrder	1.30E+05	1.30E+05	0.0	66	66	0.0	1.10E+08	-	-	6.86E+10	-	-
PartialOrder	1.35E+05	1.35E+05	0.0	114	114	0.0	4.11E+05	4.11E+05	0.0	3.30E+07	3.30E+07	0.0
PreOrder	2.09E+05	2.09E+05	0.0	75	75	0.0	1.88E+08	-	-	6.85E+10	-	-
Reflexive	1.05E+06	1.05E+06	0.0	0	0	0.0	0	0	0.0	3.25E+07	3.25E+07	0.0
StrictOrder	1.30E+05	1.30E+05	0.0	31	31	0.0	1.48E+08	-	-	6.86E+10	-	-
TotalOrder	3.63E+05	3.63E+05	0.0	0	-	-	-	-	-	-	-	-
Transitive	1.53E+05	1.53E+05	0.0	1338	1338	0.0	7.90E+05	7.90E+05	0.0	3.26E+07	3.26E+07	0.0

Table 4: Table 4 - *QuantifyML* - Decision Trees - The number of primary variables and total number of clauses are tabulated for each of the four cases considered (i.e., true positive (TP), false negative (FN), false positive (FP), and true negative (TN)).

Property	Primary Variables	Clauses			
		True Positives	False Negatives	False Positives	True Negatives
Antisymmetric	16	3731	3825	3743	3837
Connex	16	1231	1188	928	900
Irreflexive	16	132	155	114	128
NonStrictOrder	16	3870	3942	3124	3171
PartialOrder	16	7427	7543	7417	7521
PreOrder	16	4143	4113	3526	3504
Reflexive	16	170	154	140	130
StrictOrder	16	3270	3377	2850	1105
Transitive	16	12588	12574	12651	12637

Table 5: Table 5 - *QuantifyML* - Neural Networks - The number of primary variables and total number of clauses are tabulated for each of the four cases considered (i.e., true positive (TP), false negative (FN), false positive (FP), and true negative (TN)).

Property	Primary Variables	Clauses			
		True Positives	False Negatives	False Positives	True Negatives
Antisymmetric	16	979496	979493	979496	979493
Connex	16	979303	979295	979260	979257
Irreflexive	16	977680	977674	977668	977665
NonStrictOrder	16	979498	979490	978862	978859
PartialOrder	16	979021	979017	979449	979446
PreOrder	16	984947	984940	984610	984607
Reflexive	16	976226	976220	976214	976211
StrictOrder	16	983108	983101	982771	982768
Transitive	16	978063	978060	978063	978060

Table 6: Table 6 - Quantifying robustness for the MNIST model - The number of primary variables and total number of clauses.

Label	Variables	Clauses
0	25088	30834437
1	25088	30559298
2	25088	30732685
3	25088	30819983
4	25088	30762196
5	25088	30828172
6	25088	30224216
7	25088	30810223
8	25088	30832412
9	25088	30798957