

タイルの配置形状を緩和した Tantrix MatchのNP完全性

第8回 組合せゲーム・パズルミニ研究集会

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研究背景と目的

Tantrix[®] のタイルについて

[Colour of Strategy Ltd.]



路の組み合わせが4種類

路の色が4種類

全56種類

12種



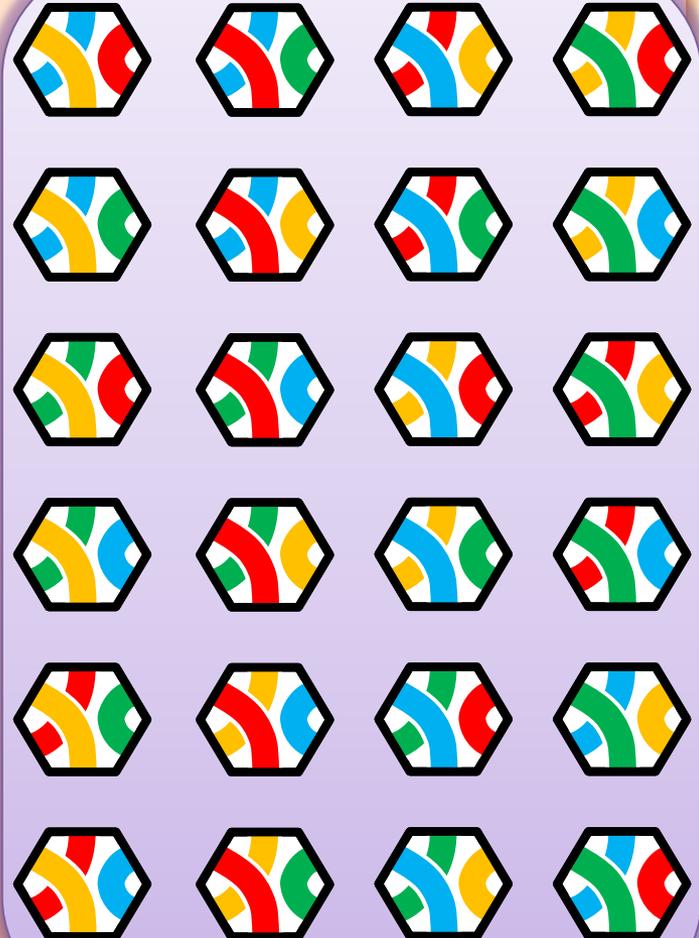
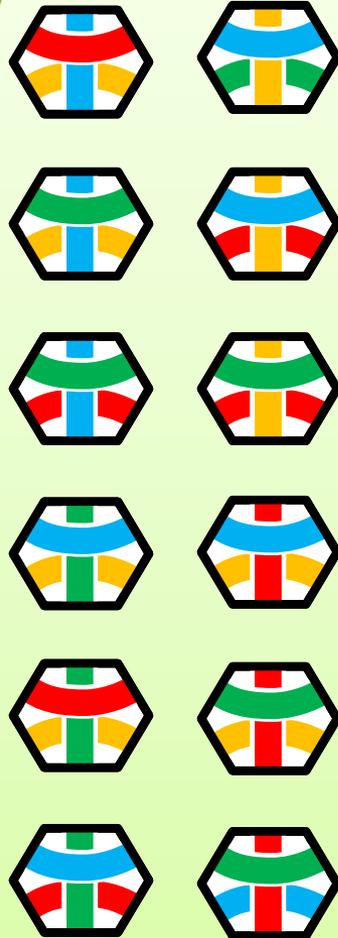
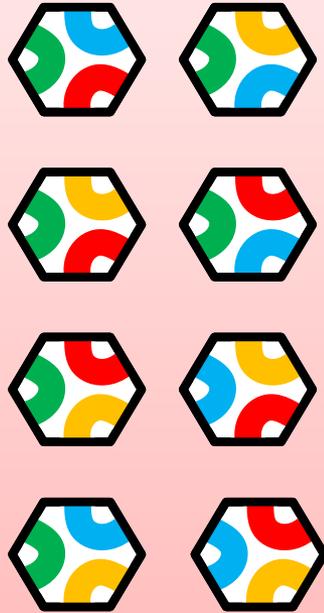
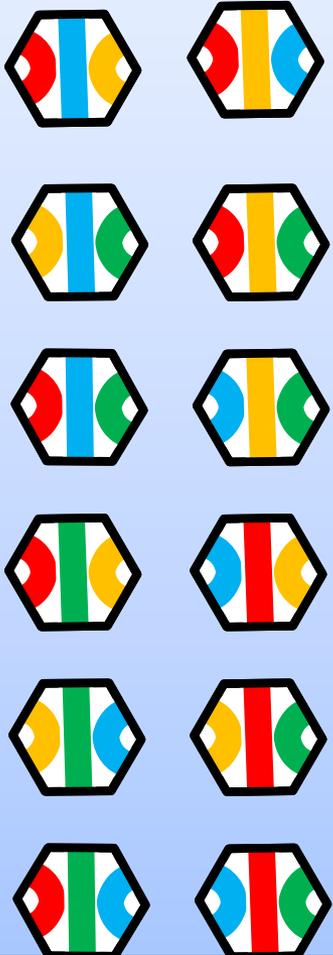
8種



12種

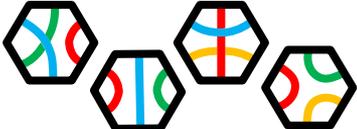
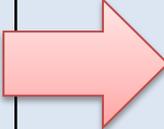


24種

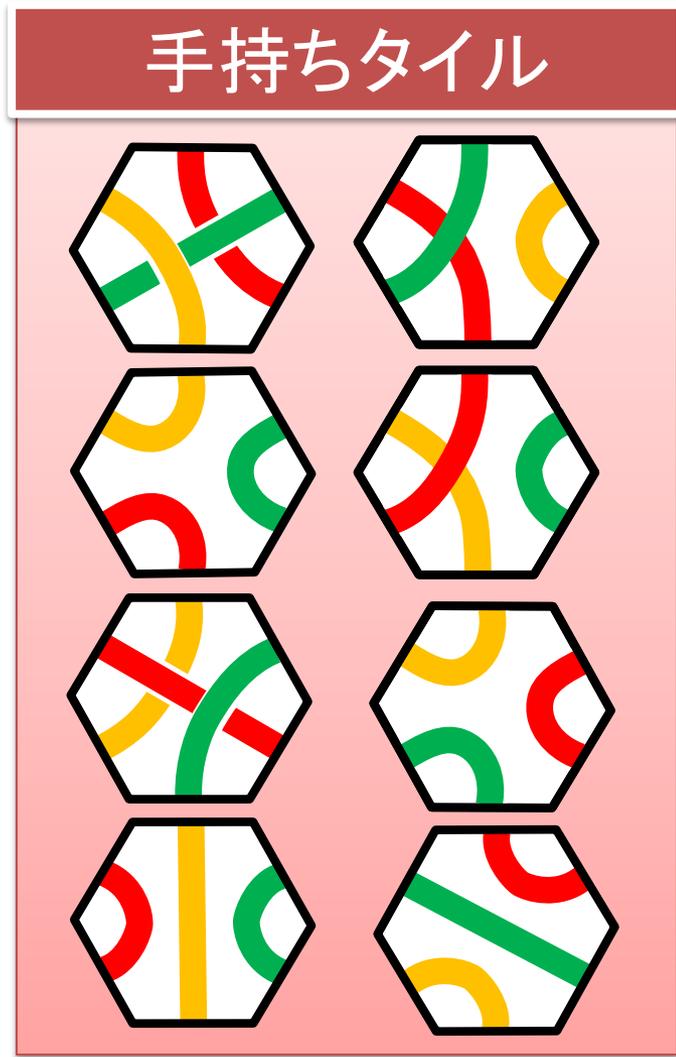
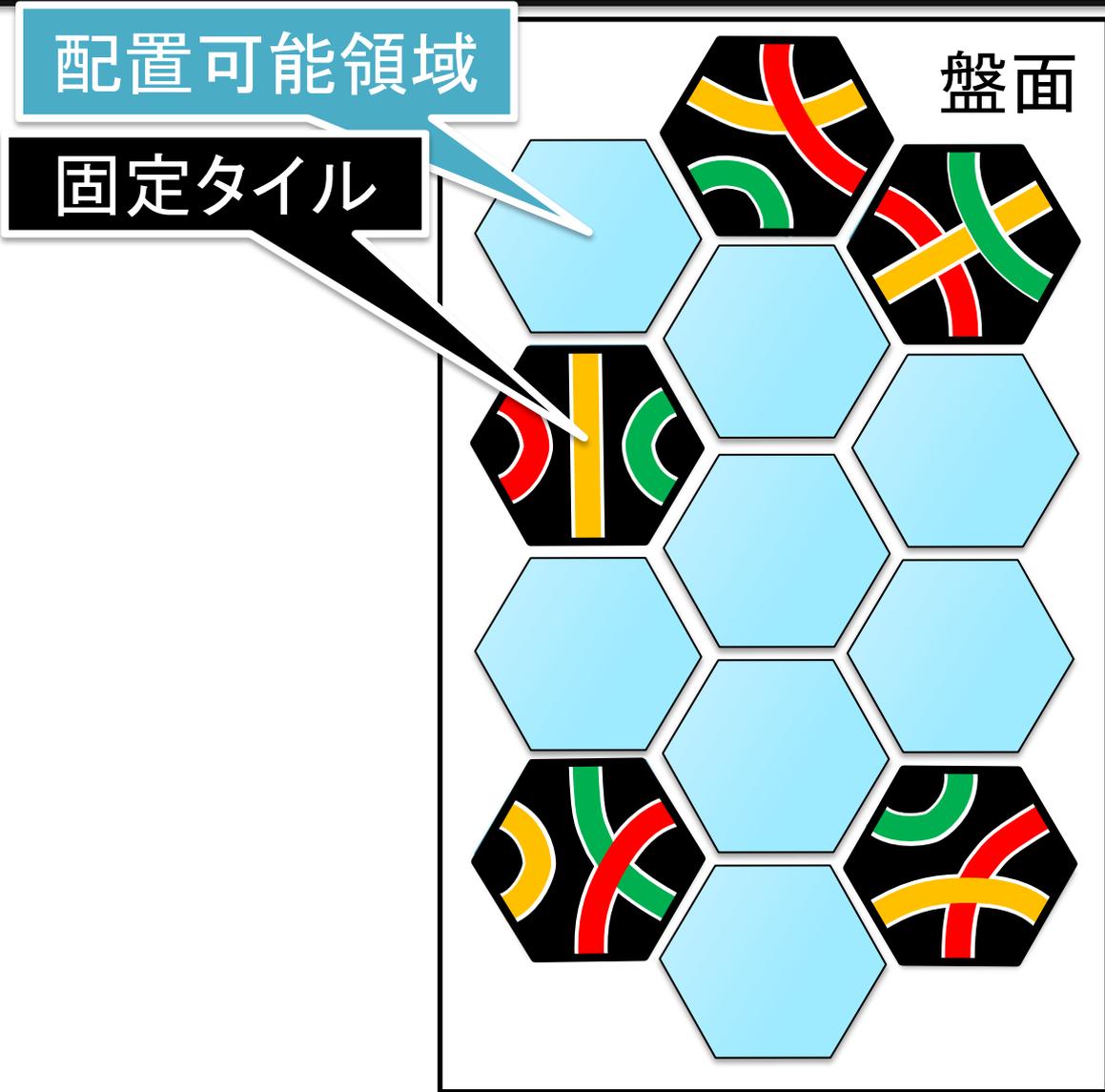


研究背景と目的

一般化Tantrix Matchの計算複雑さ

路 \ タイル	...	 × 10	...	 × 13	...	 × 17	...
	?	?	?	?	?	?	?
	?	?	?	?	?	NP 完全	
	?	NP 完全					
	?	NP 完全		NP 完全	 [Uejima et al., 2013]		

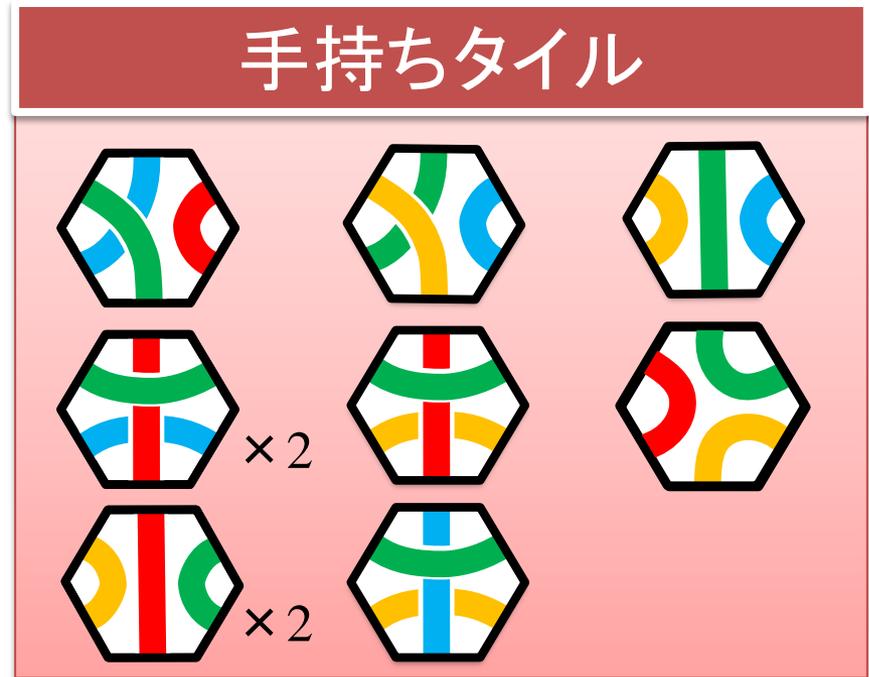
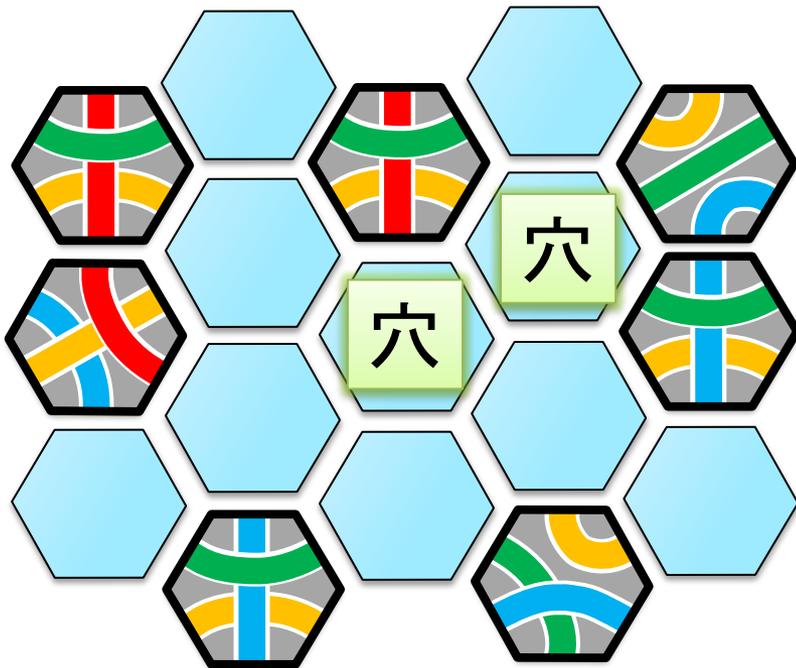
Tantrix Matchのルール



穴を許した一般化Tantrix Matchの定義

入力: 固定タイル, 配置可能領域, 手持ちタイル

質問: ルールを満たす手持ちタイルの配置は可能か?

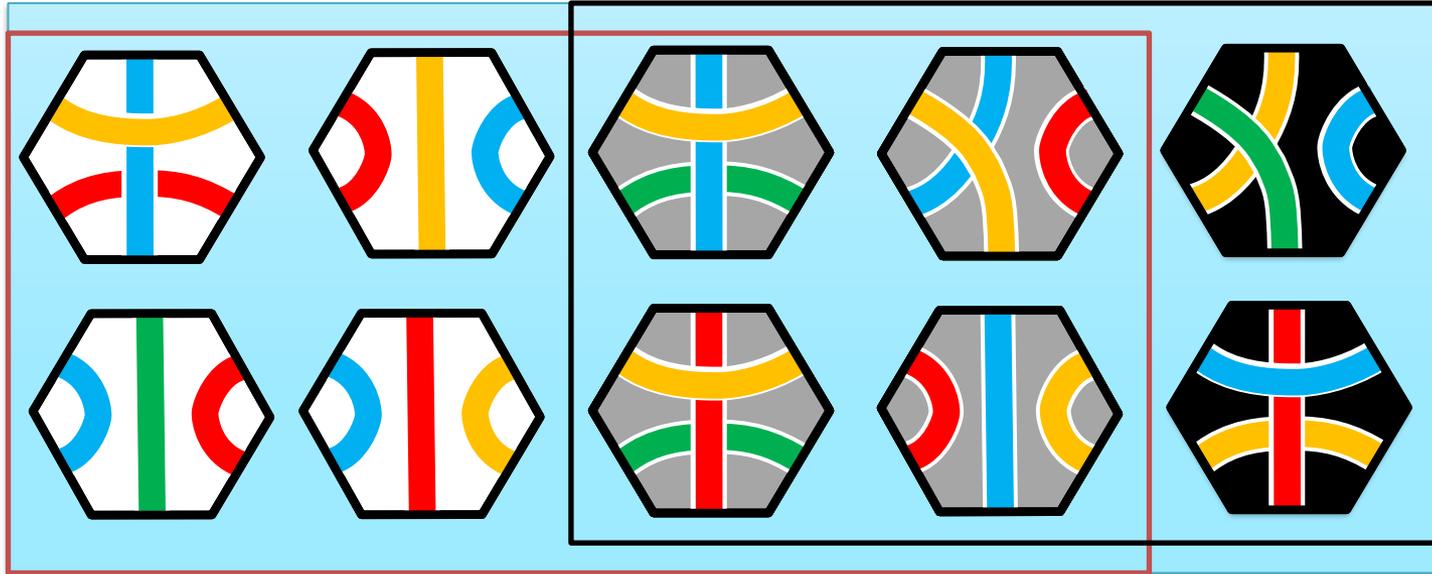


NP完全の証明

手持タイ

使用タイル

固定タイル



I. 穴を許した一般化Tantrix Match \in NP

II. 既知のNP完全問題からの多項式時間還元

→ Circuit-SAT [S. Cook, 1971]

Circuit-SAT [S. Cook, 1971.]

入力

n 個の入力変数と1つの出力 f を持つ論理回路 C

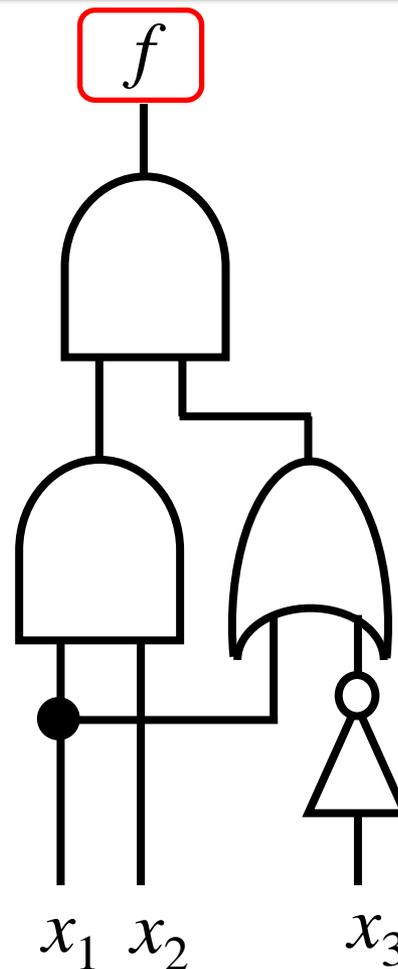
質問

出力 f の値を1とするような、真偽値の割り当てが存在するか？

還元に必要な部品

入力部	出力部	ワイヤー部
AND部	NOT部	COPY部, 調整部
交差部, OR部		

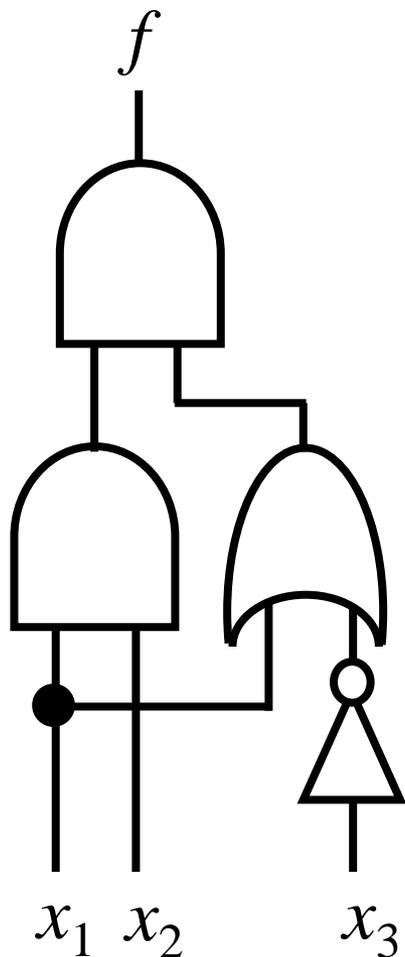
Circuit-SAT



真理値表

x_1	x_2	x_3	f
0	0	0	0
0	0	1	0
0	1	0	0
:	:	:	:
1	1	0	1
:	:	:	:
1	1	1	1

穴の必要性について



穴がない場合

部品と部品の間を埋める必要がある

臨機応変に対応する部品が構成できない

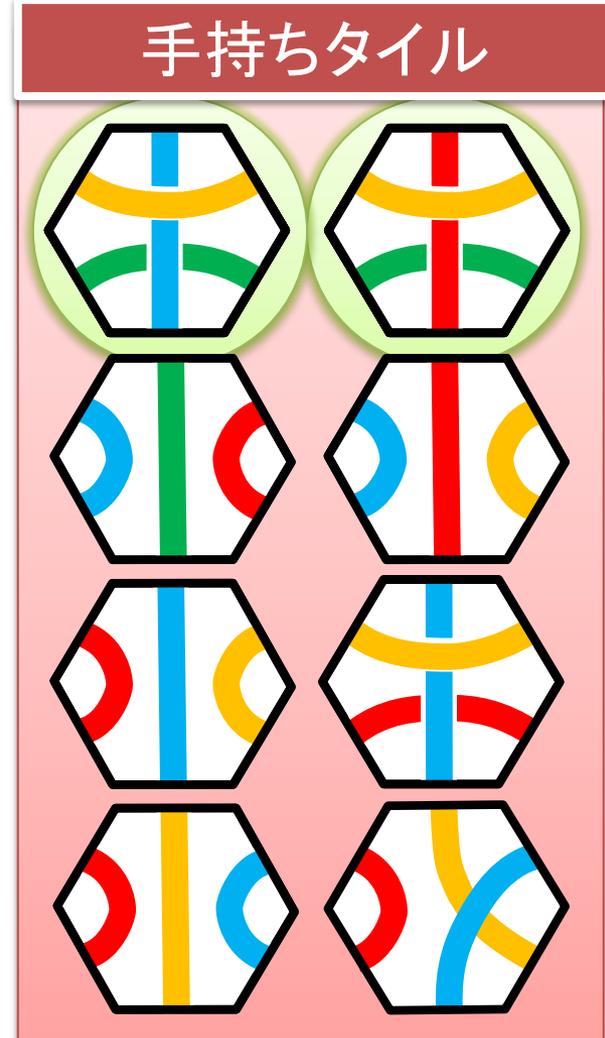
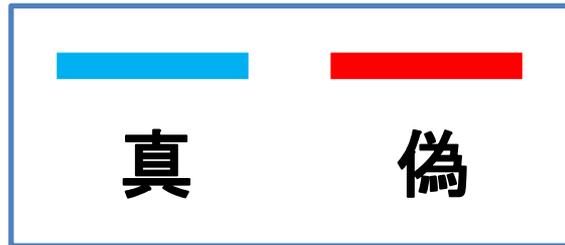
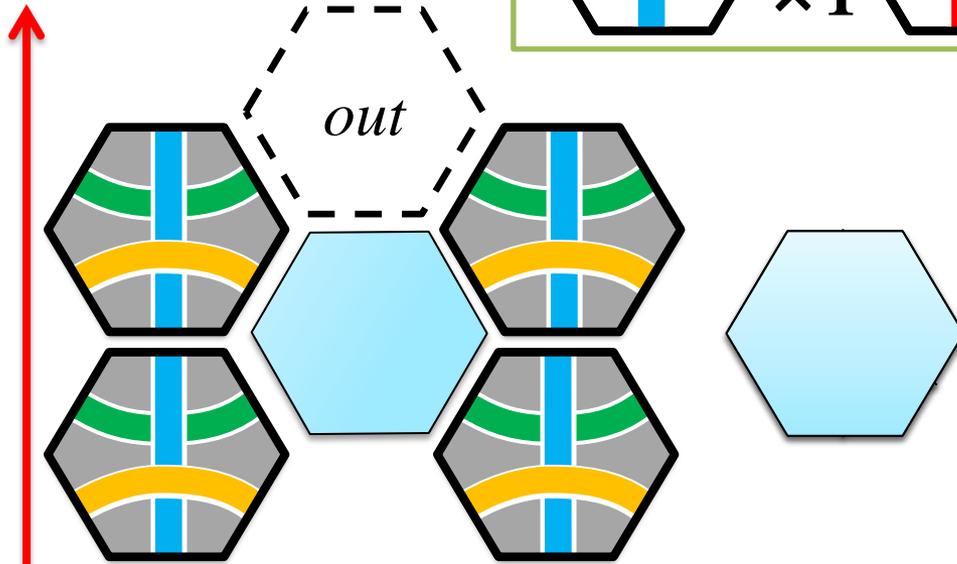
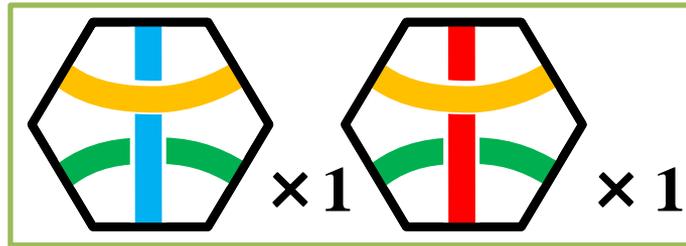


穴で配置制限を緩める

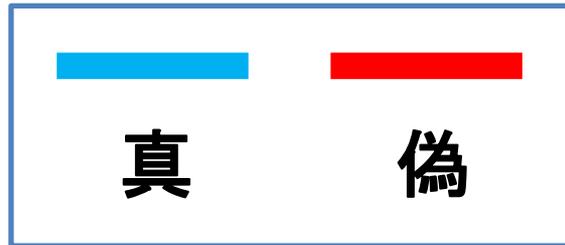
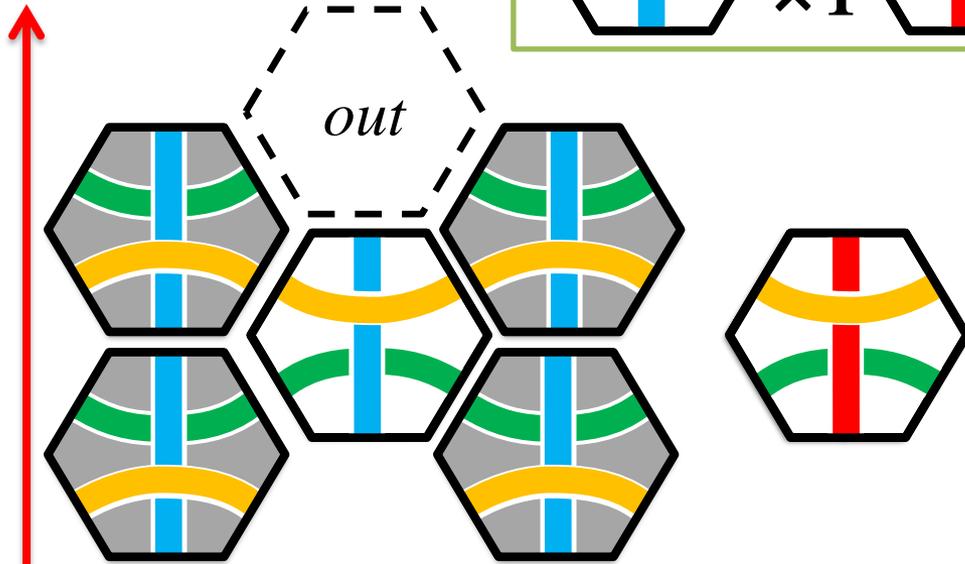
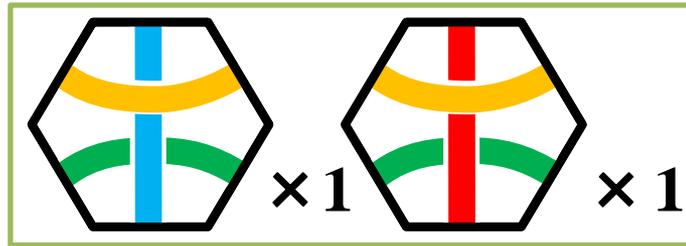
3種類の路・10種のタイル



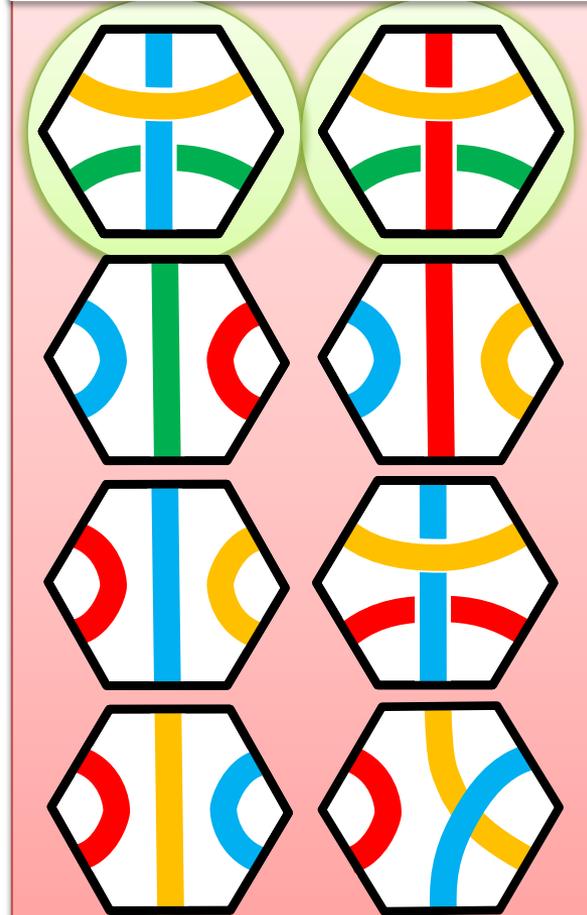
入力部



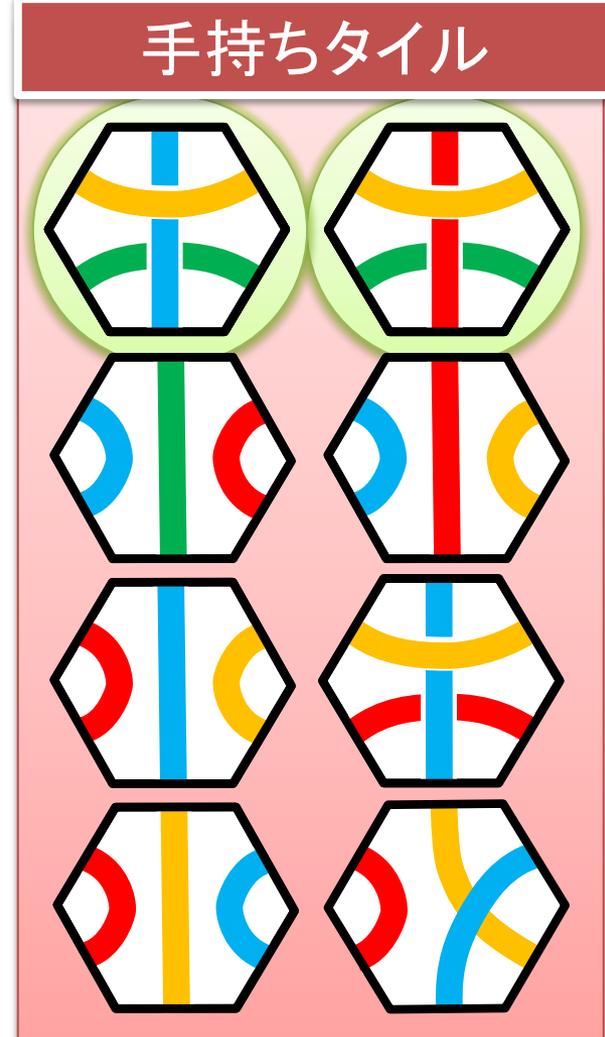
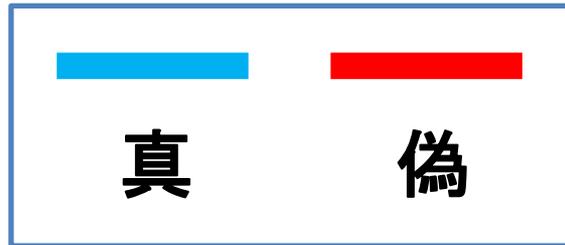
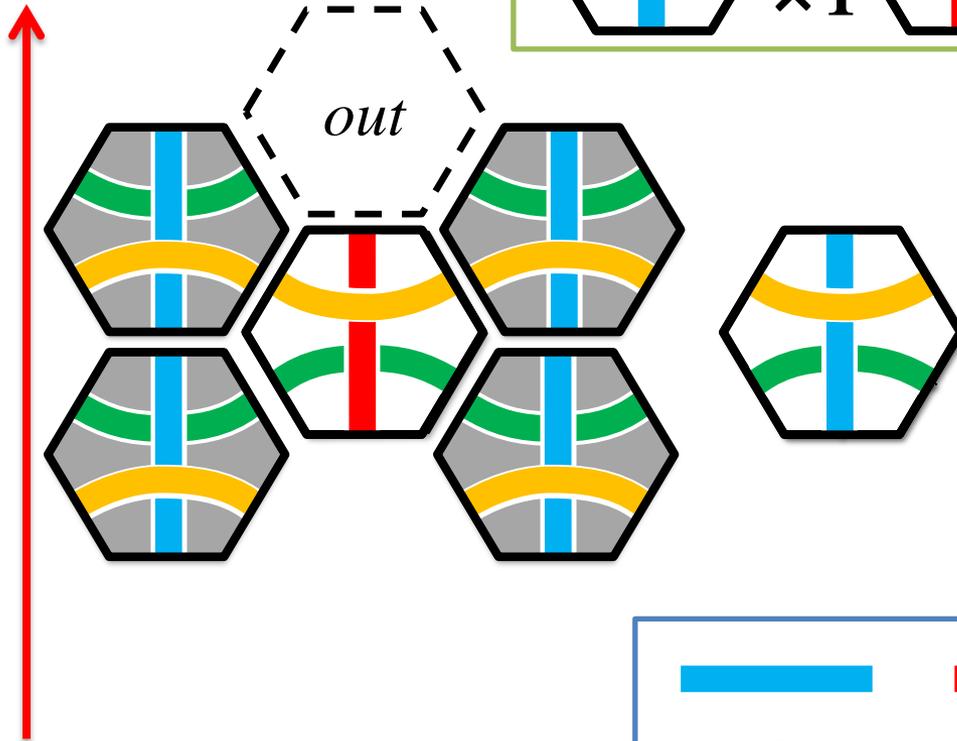
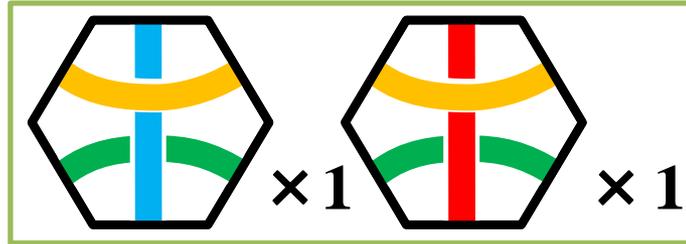
入力部



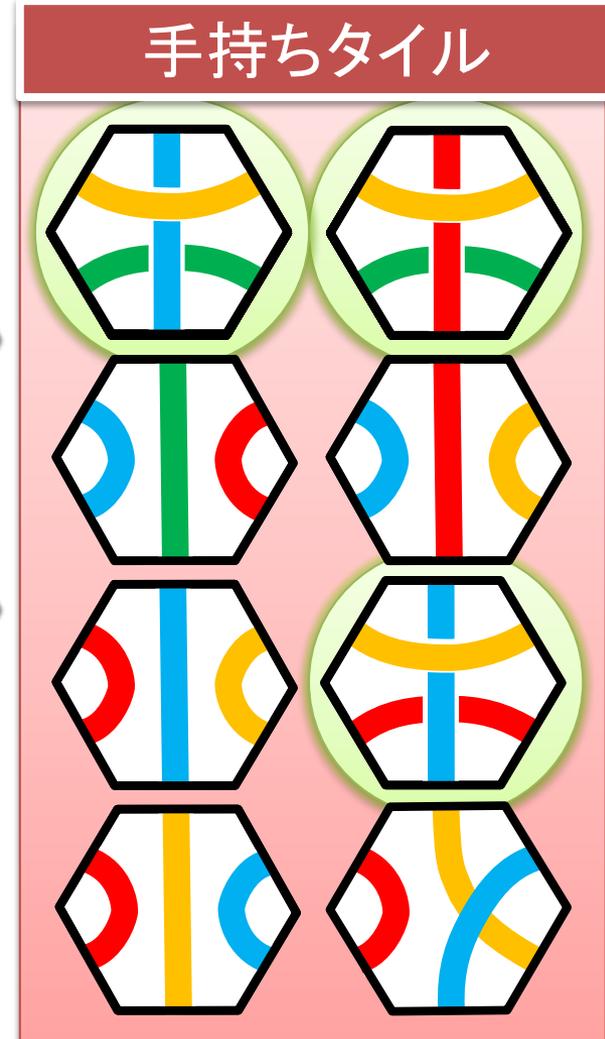
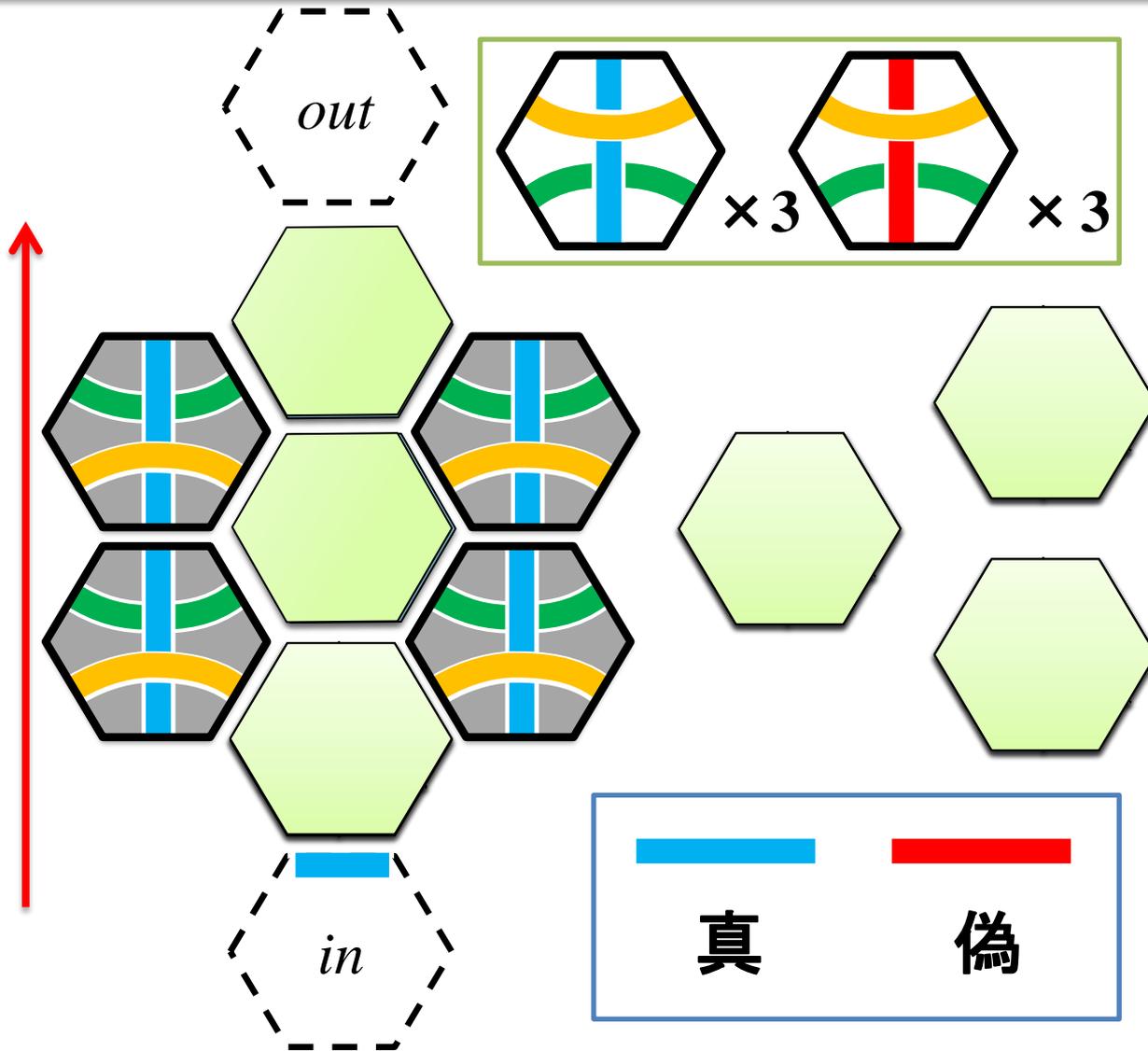
手持ちタイル



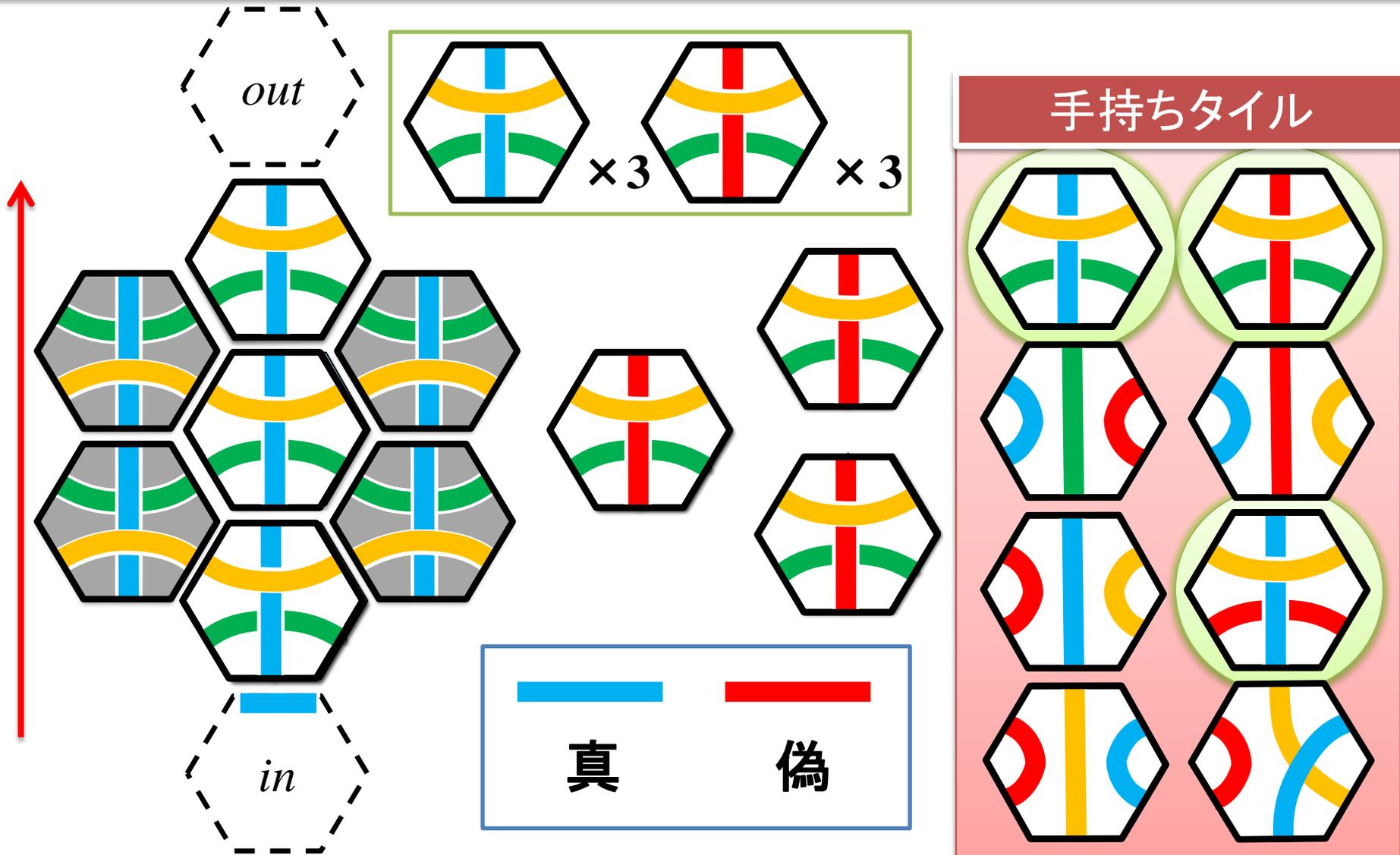
入力部



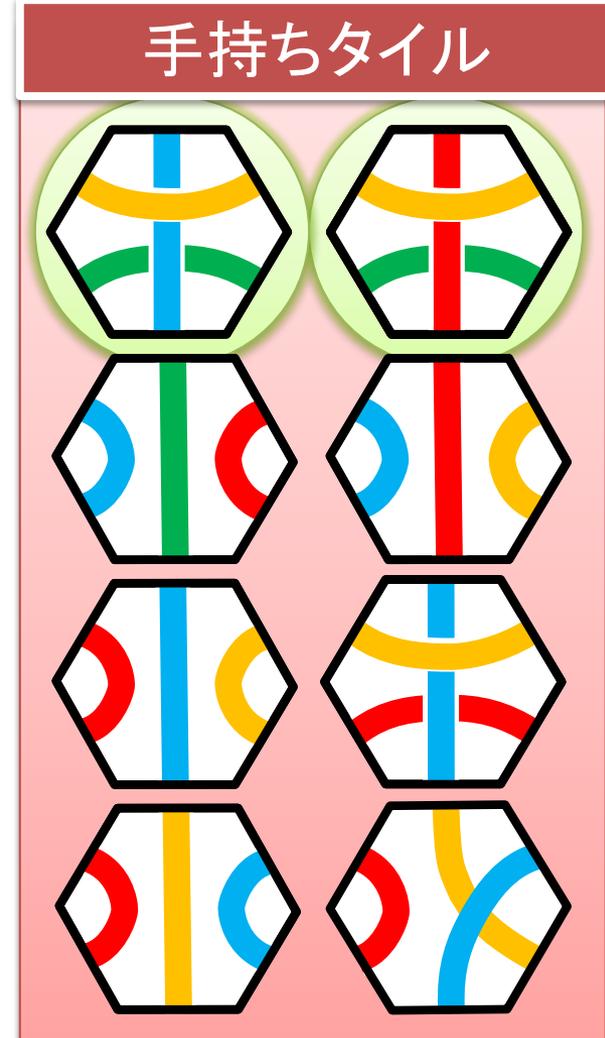
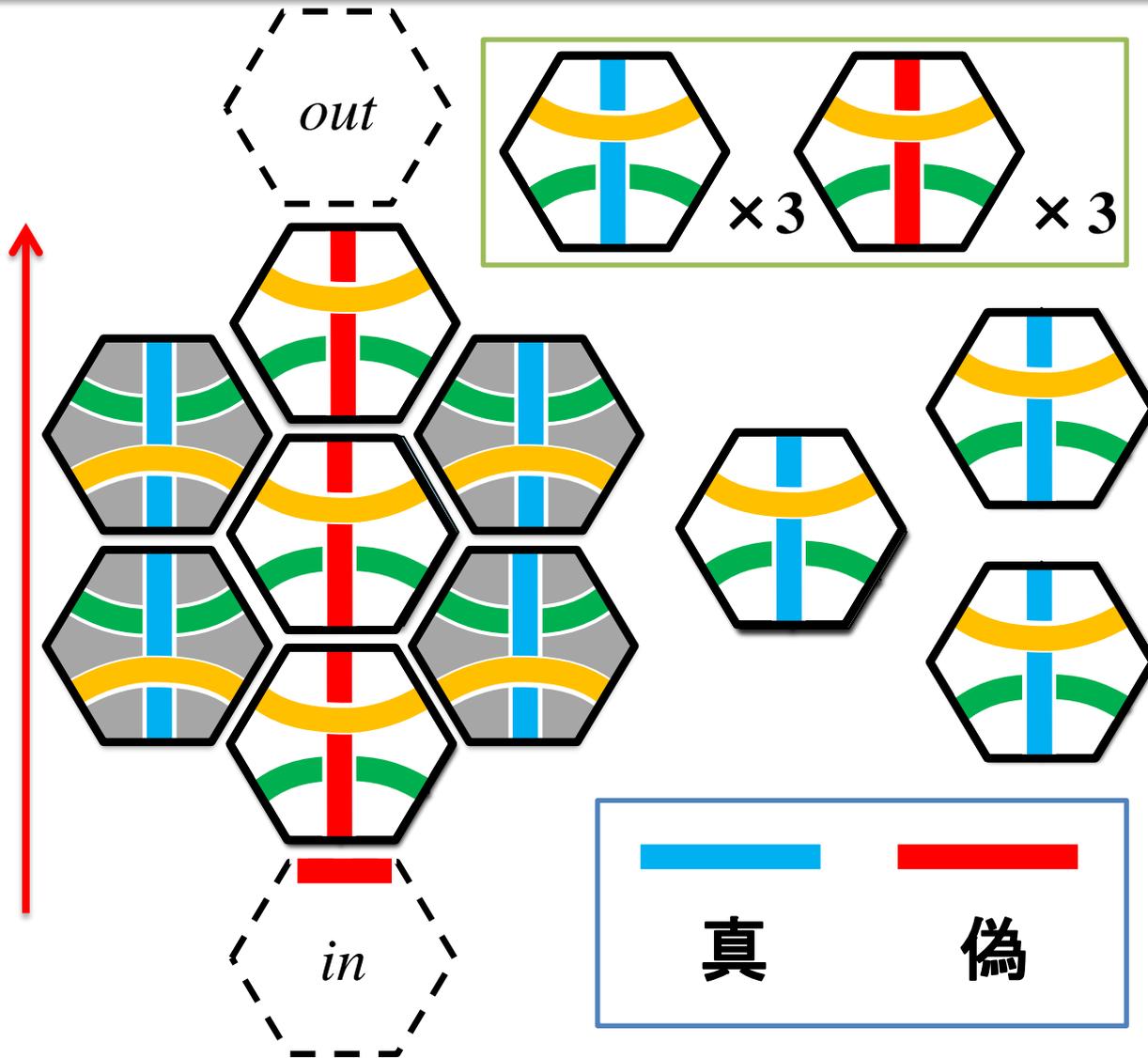
WIRE部(真の場合)



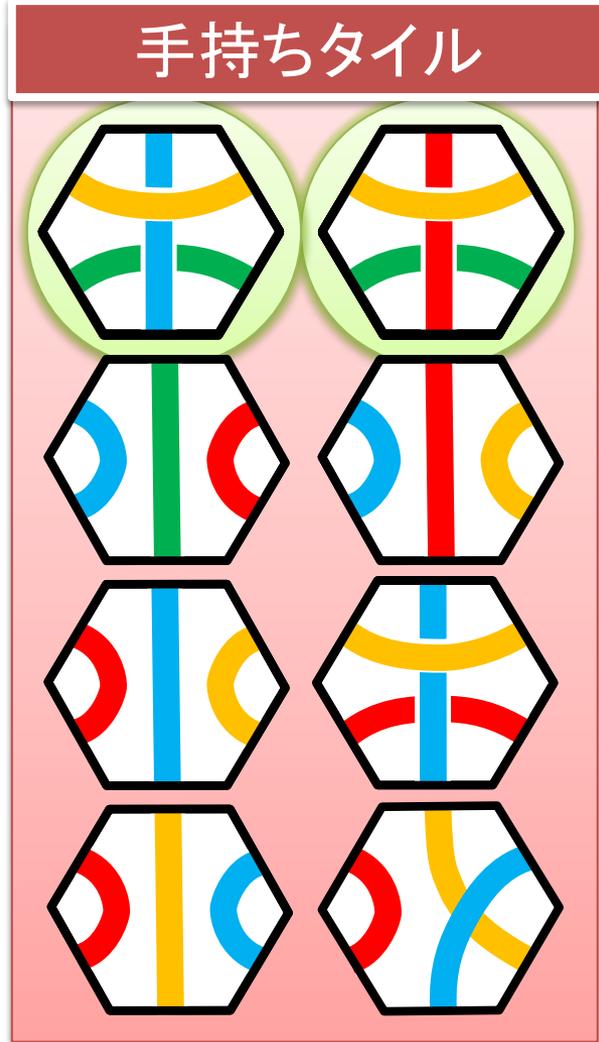
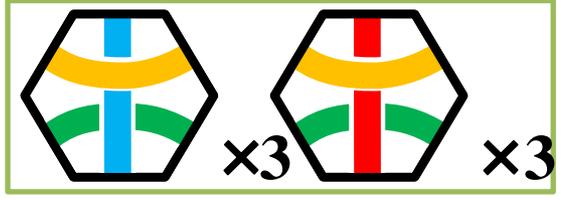
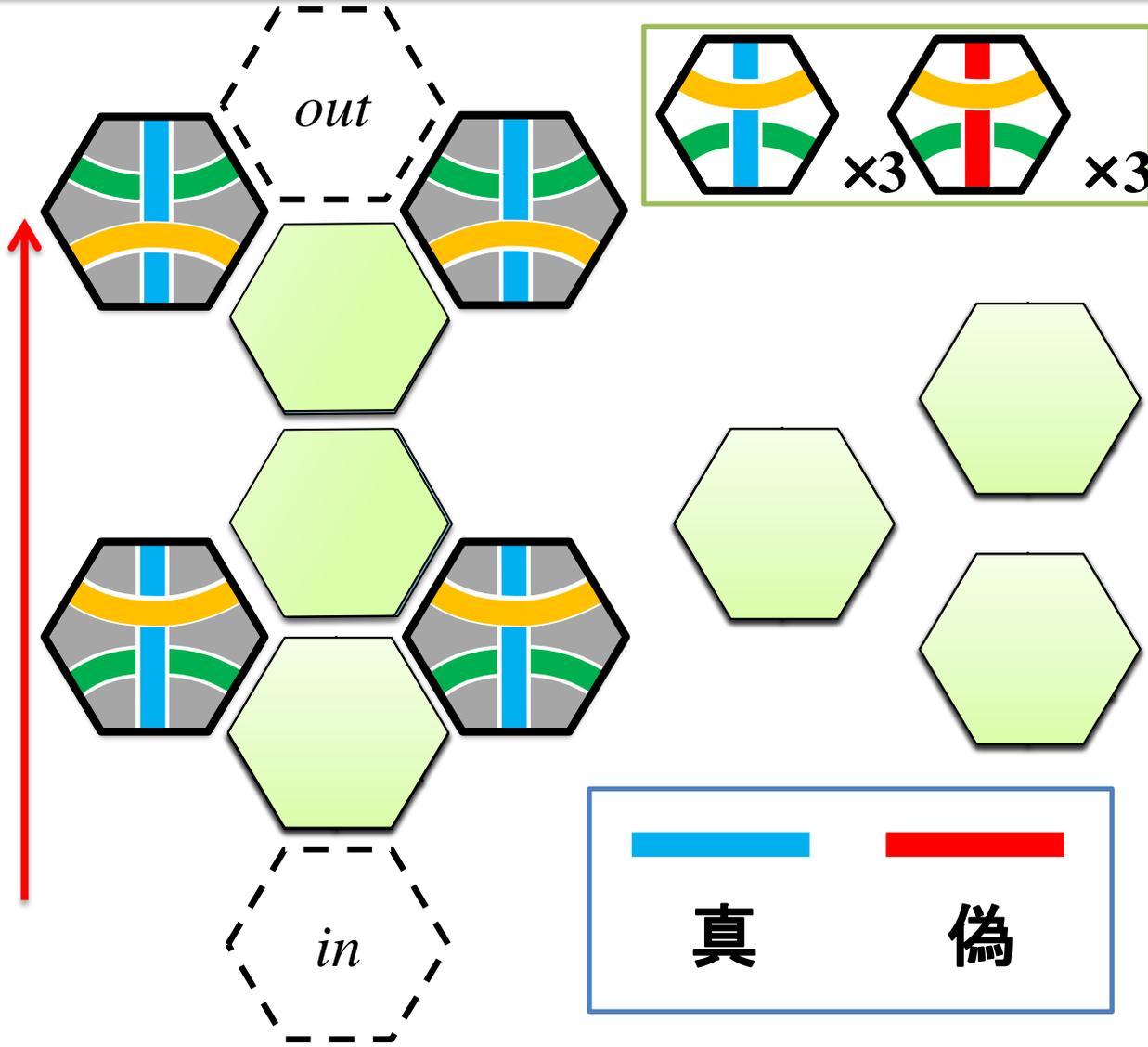
WIRE部(真の場合)



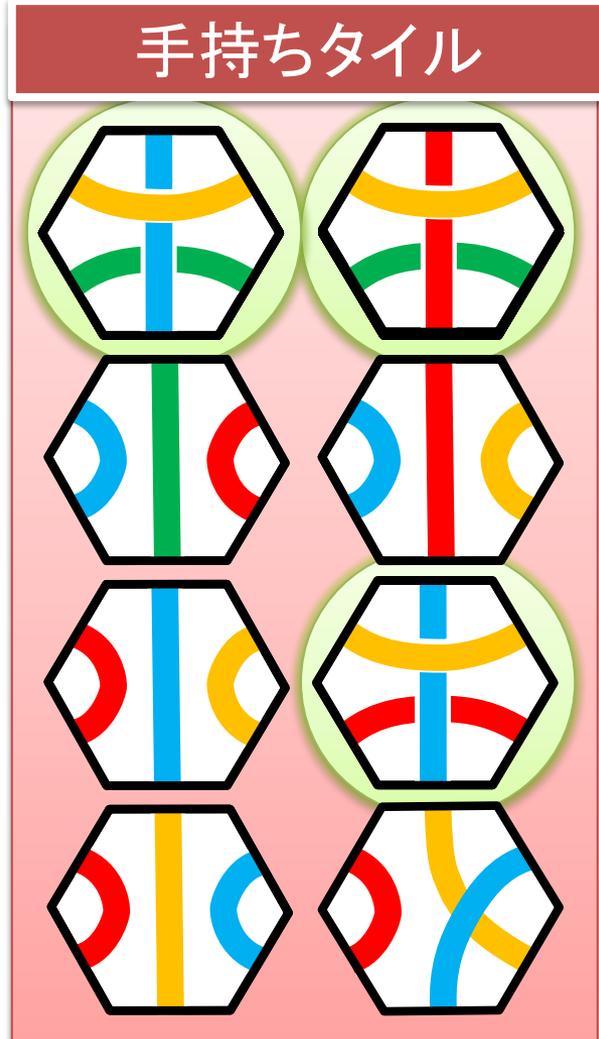
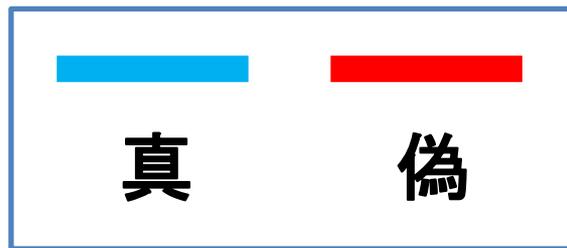
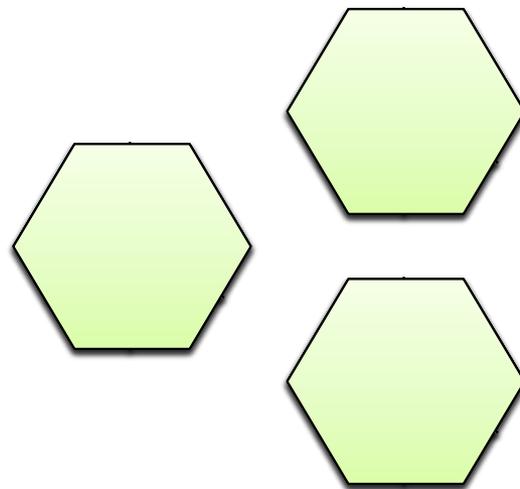
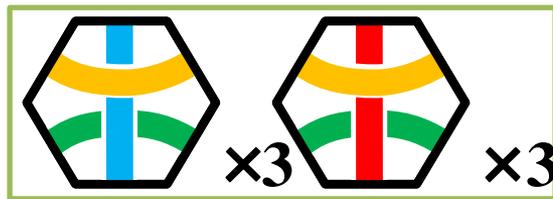
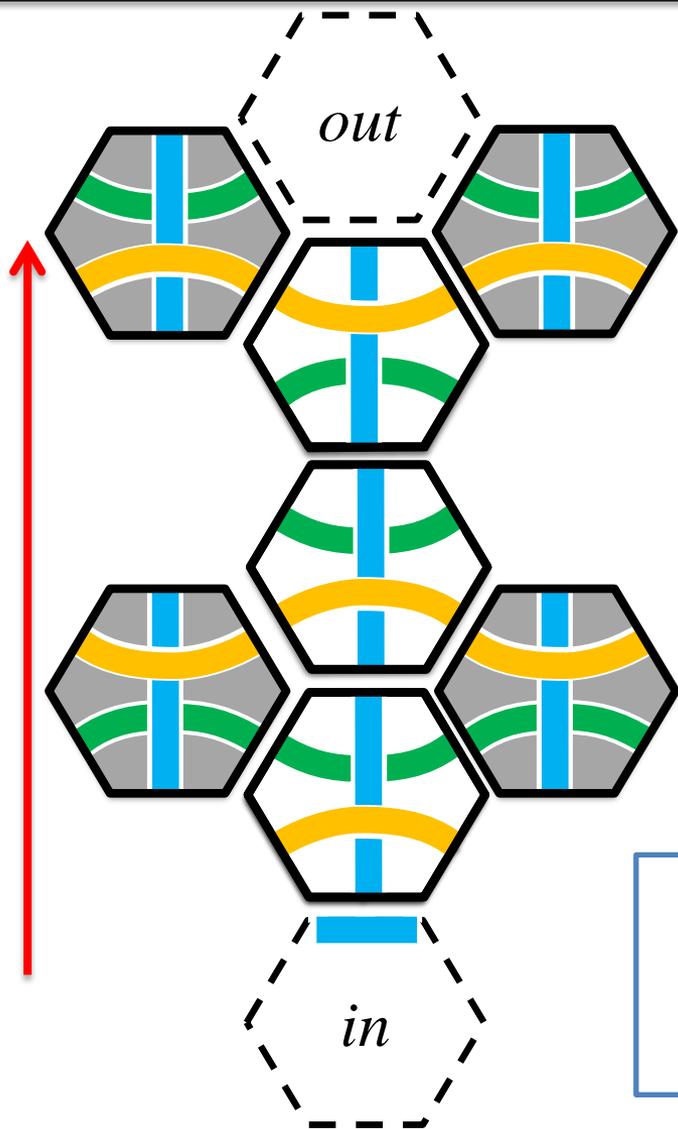
WIRE部 (偽の場合)



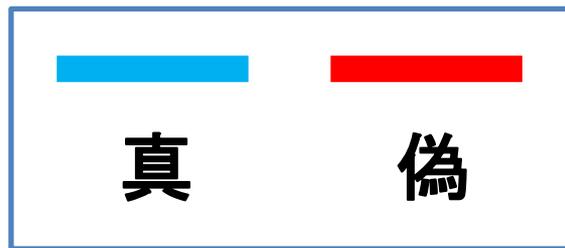
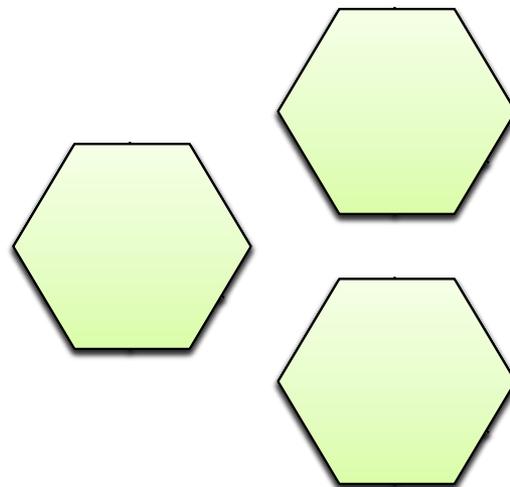
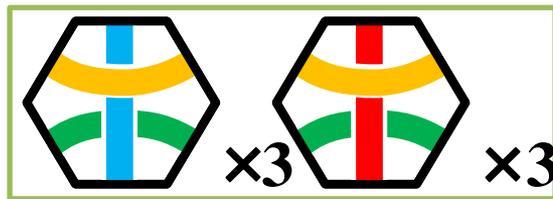
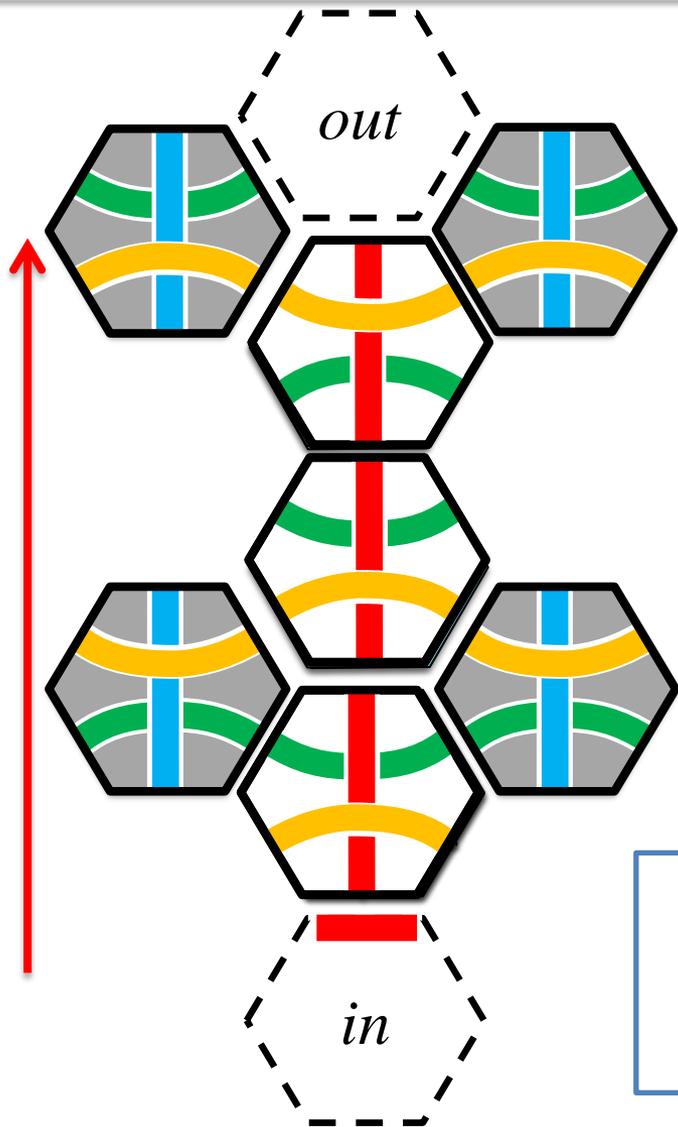
接続部



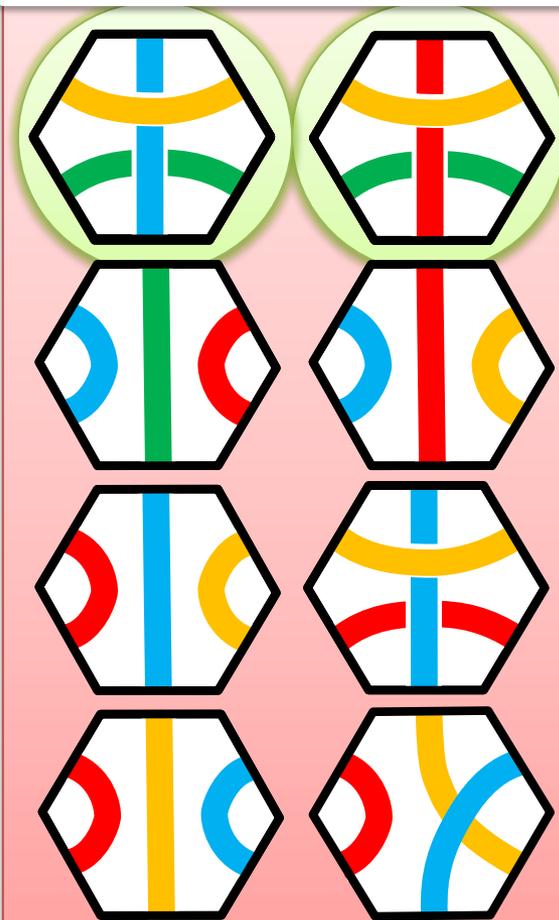
接続部（真の場合）



接続部（偽の場合）

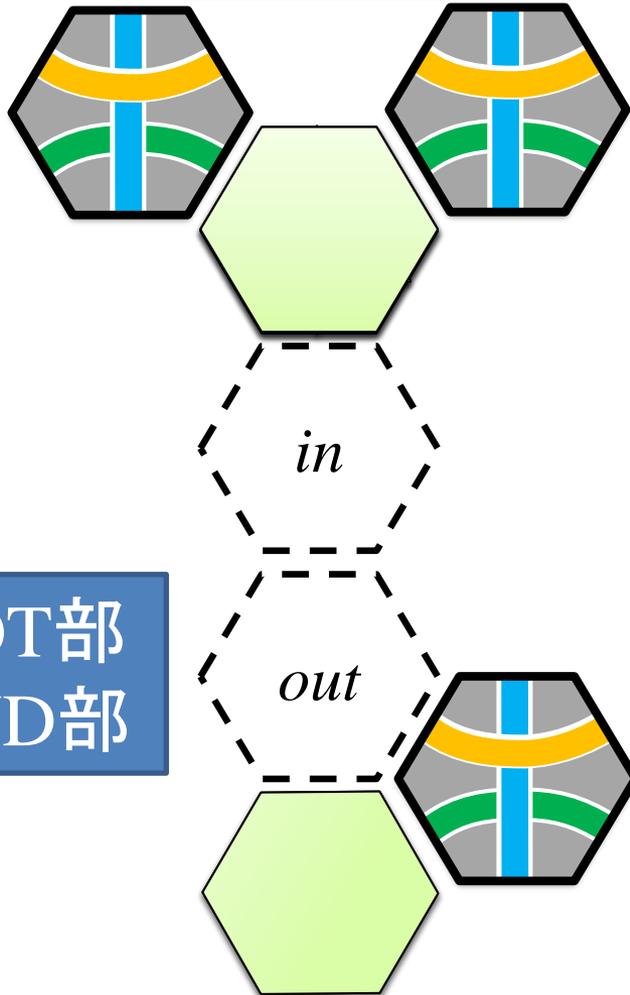


手持ちタイル



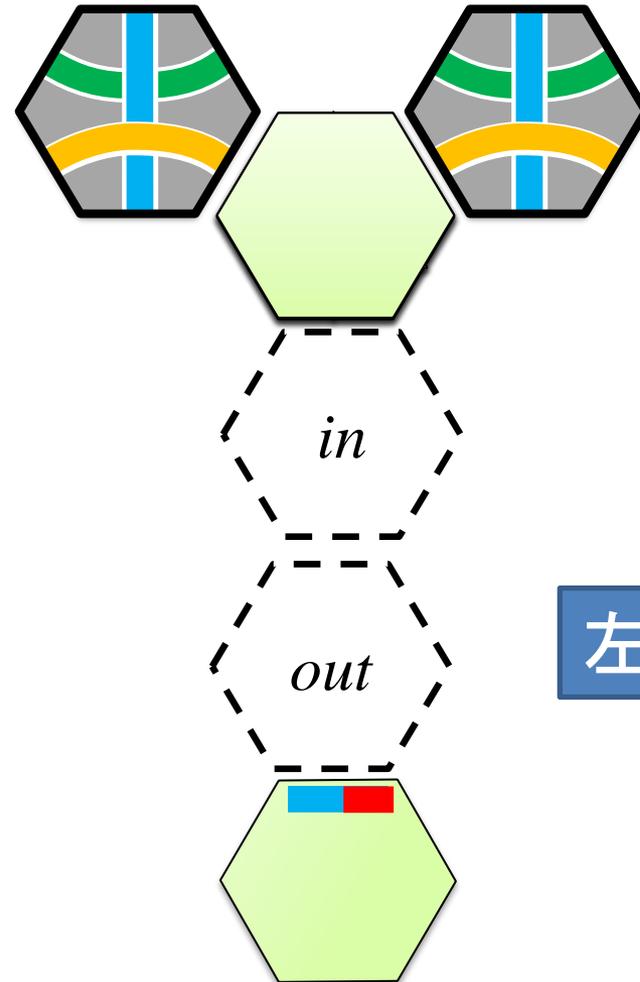
接続の方法

接続部



NOT部
AND部

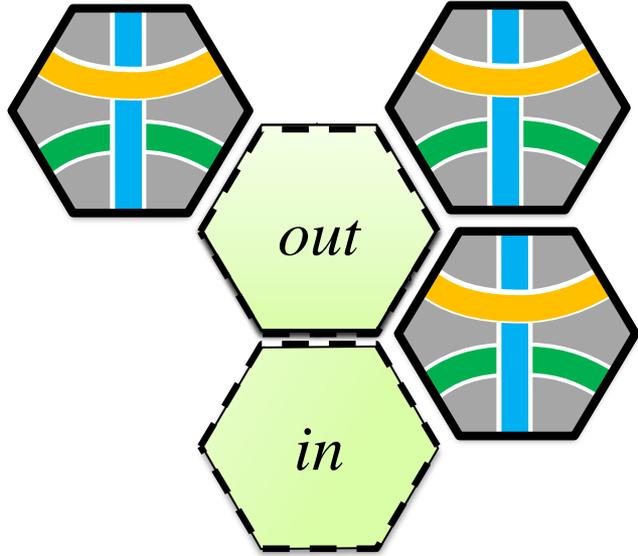
接続部以外



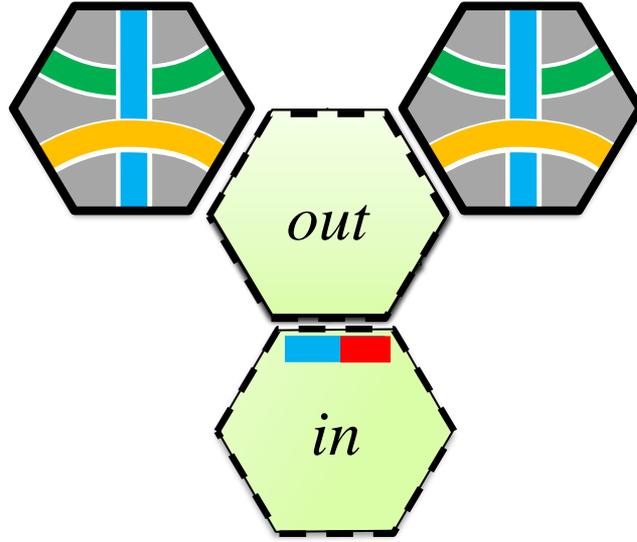
左記以外

接続の方法

接続部



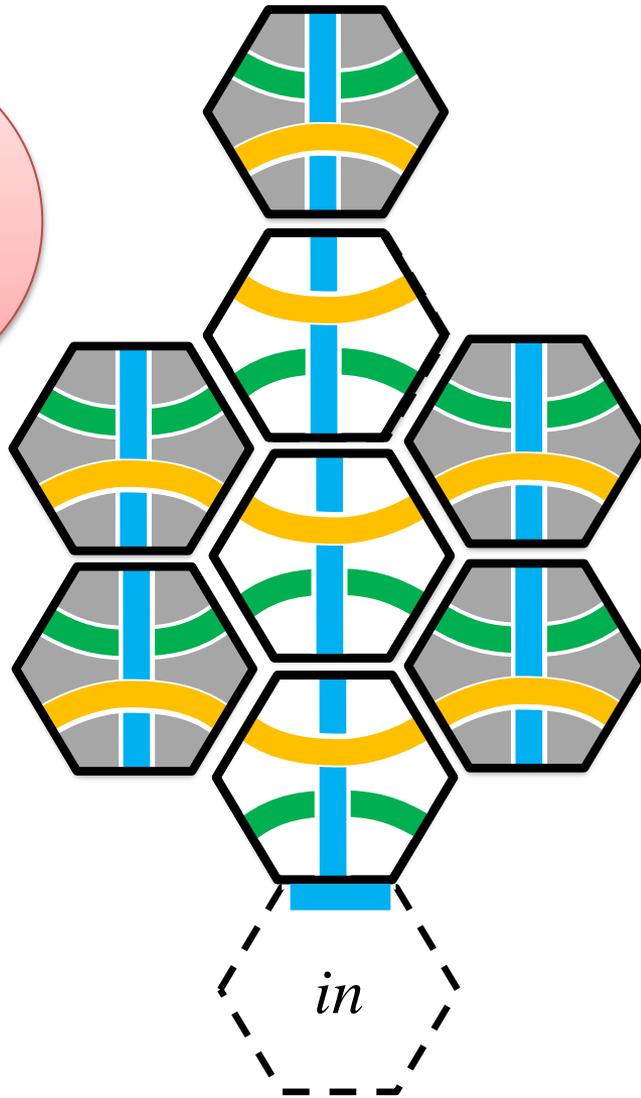
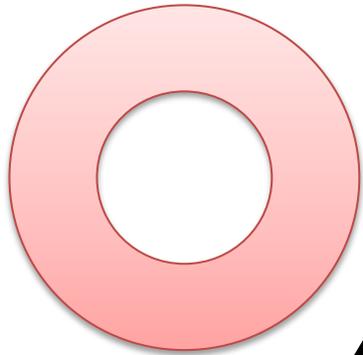
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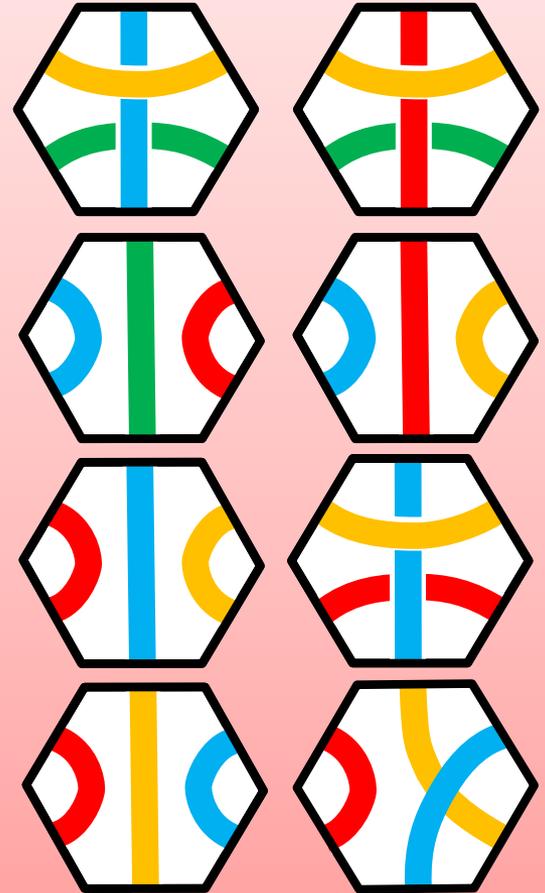
NOT部
AND部

左記以外

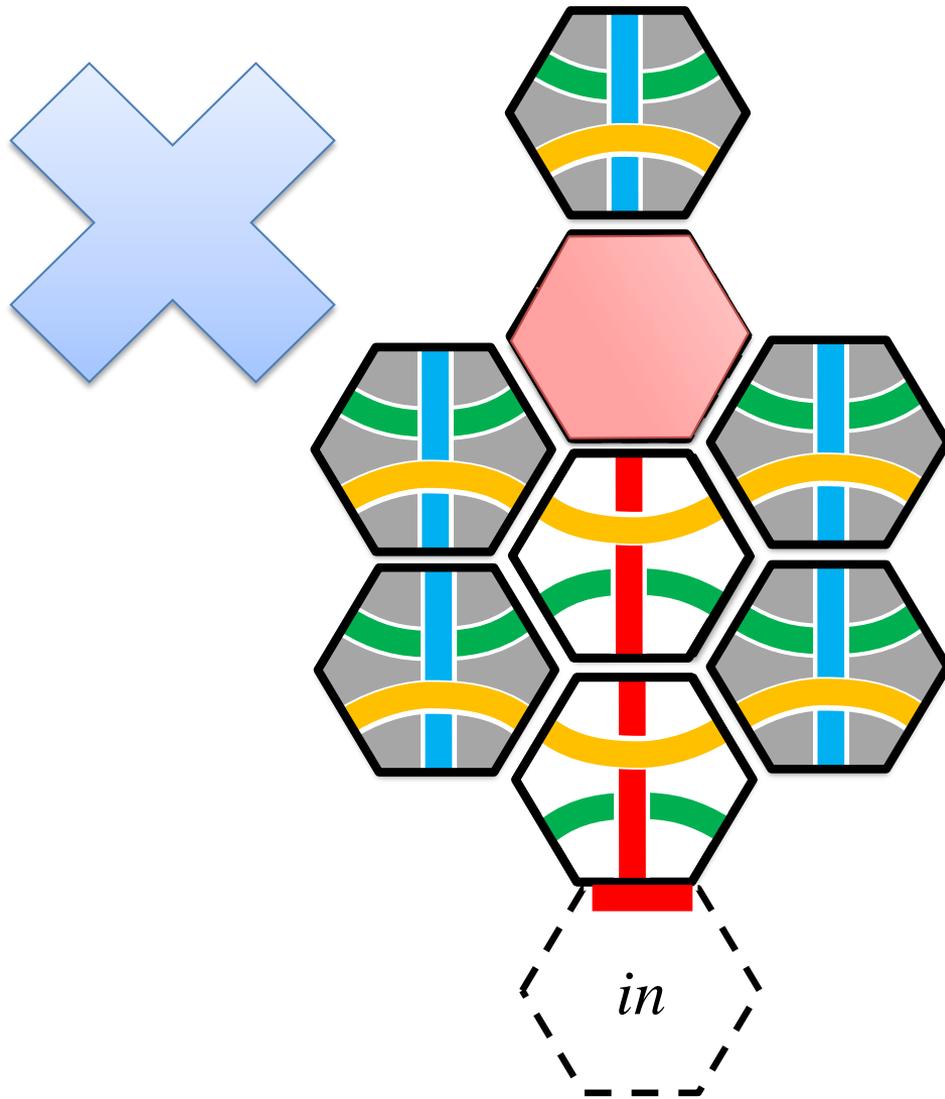
出力部



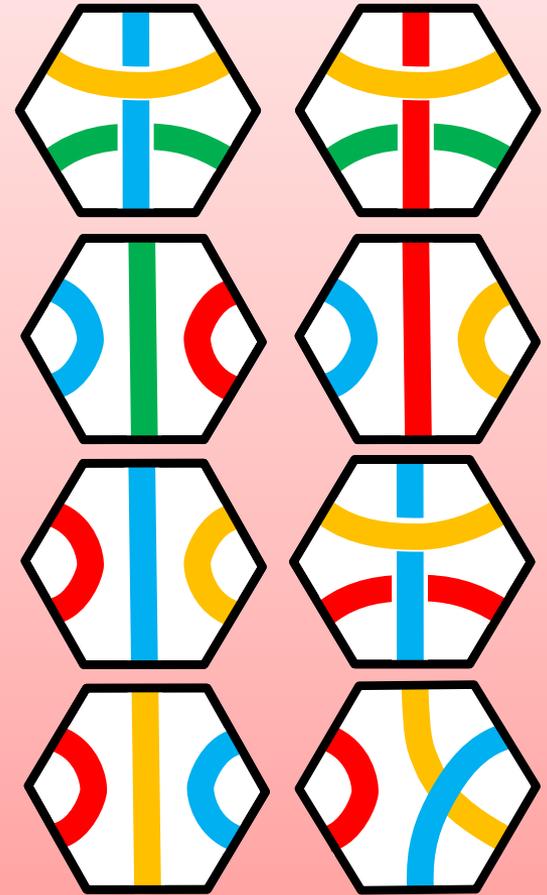
手持ちタイル



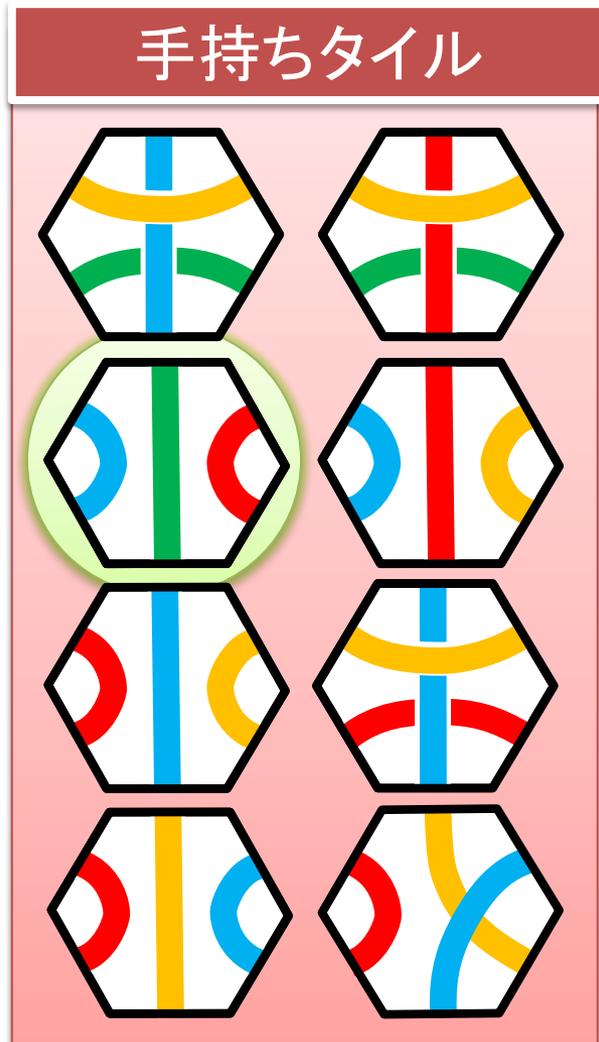
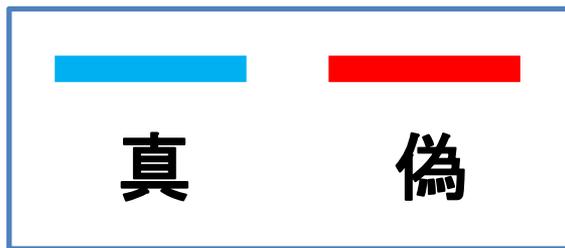
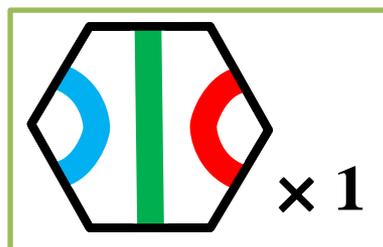
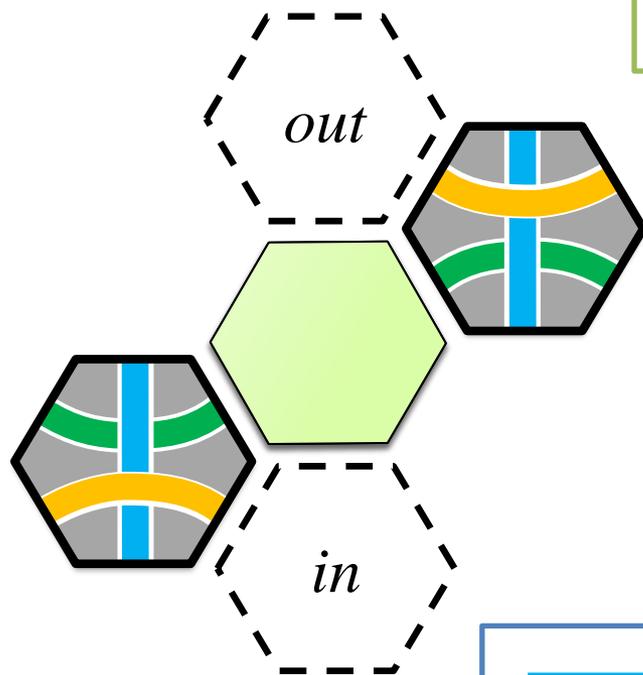
出力部



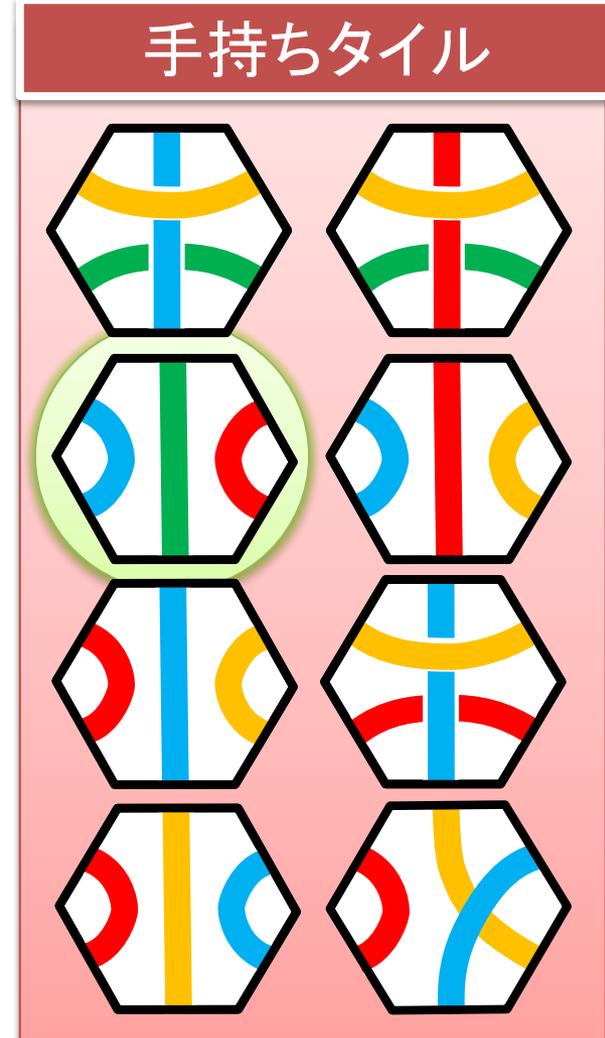
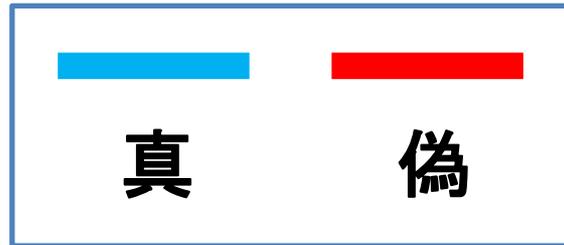
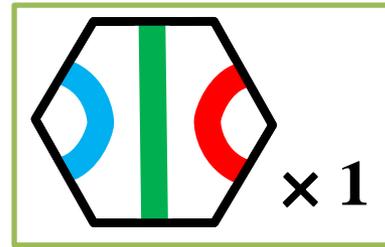
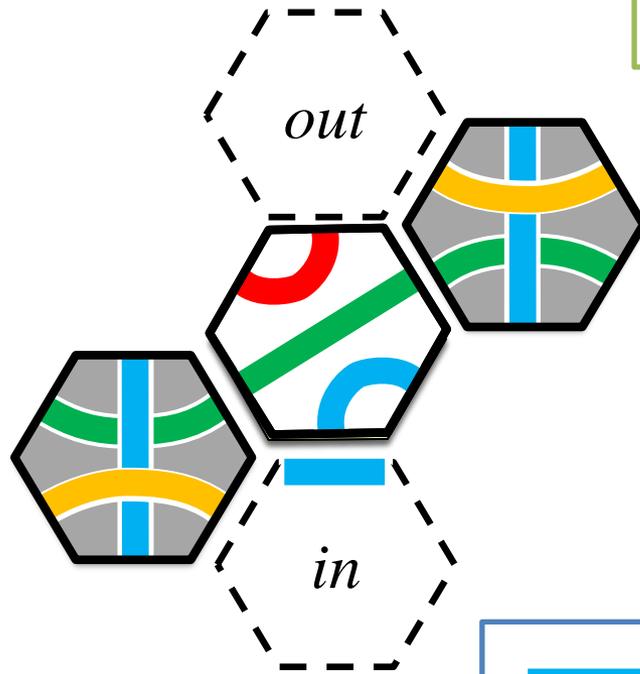
手持ちタイル



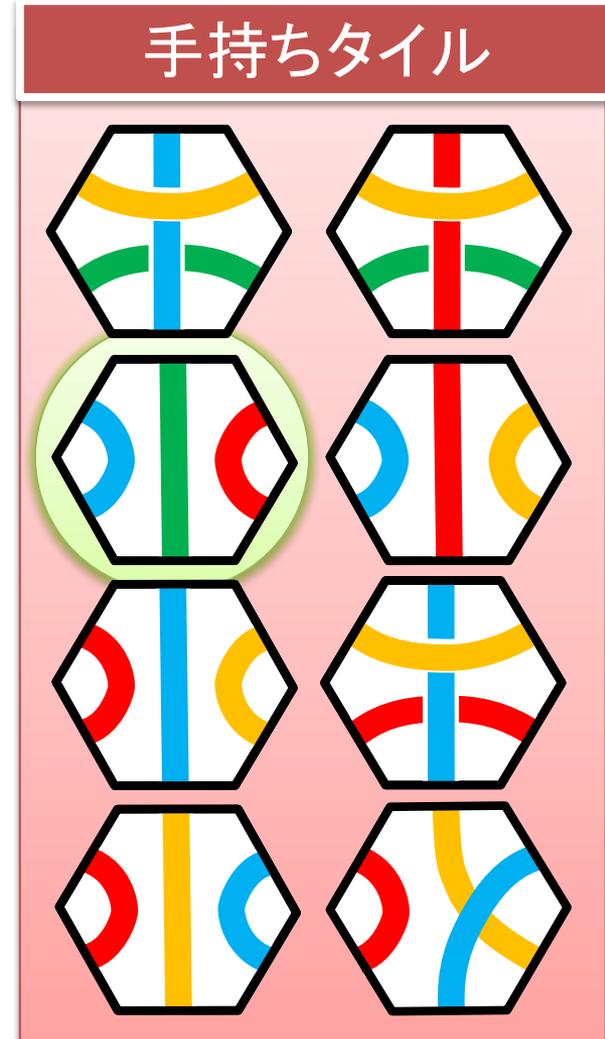
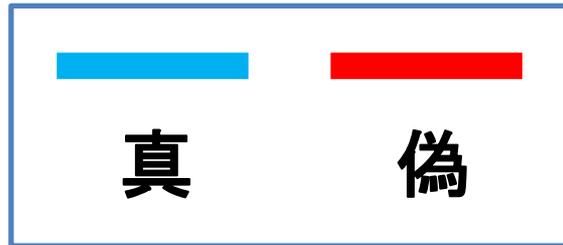
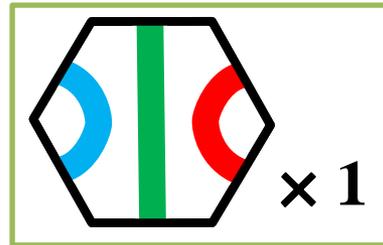
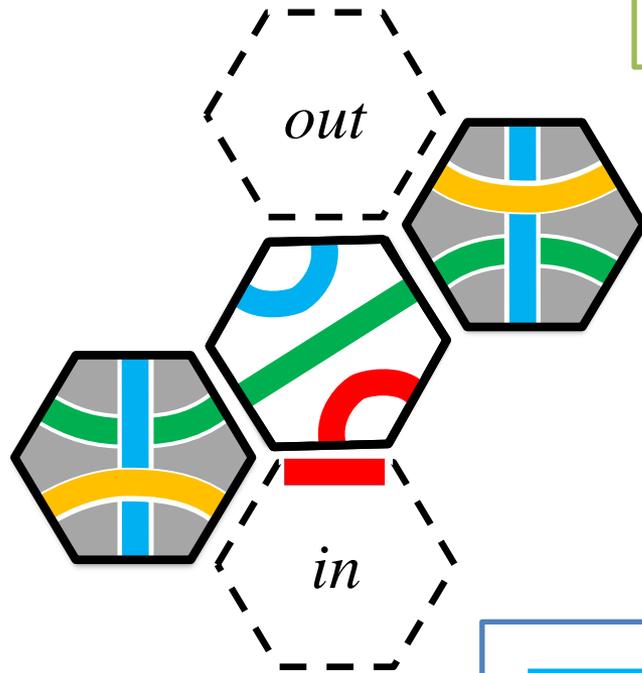
NOT部



NOT部(真の場合)

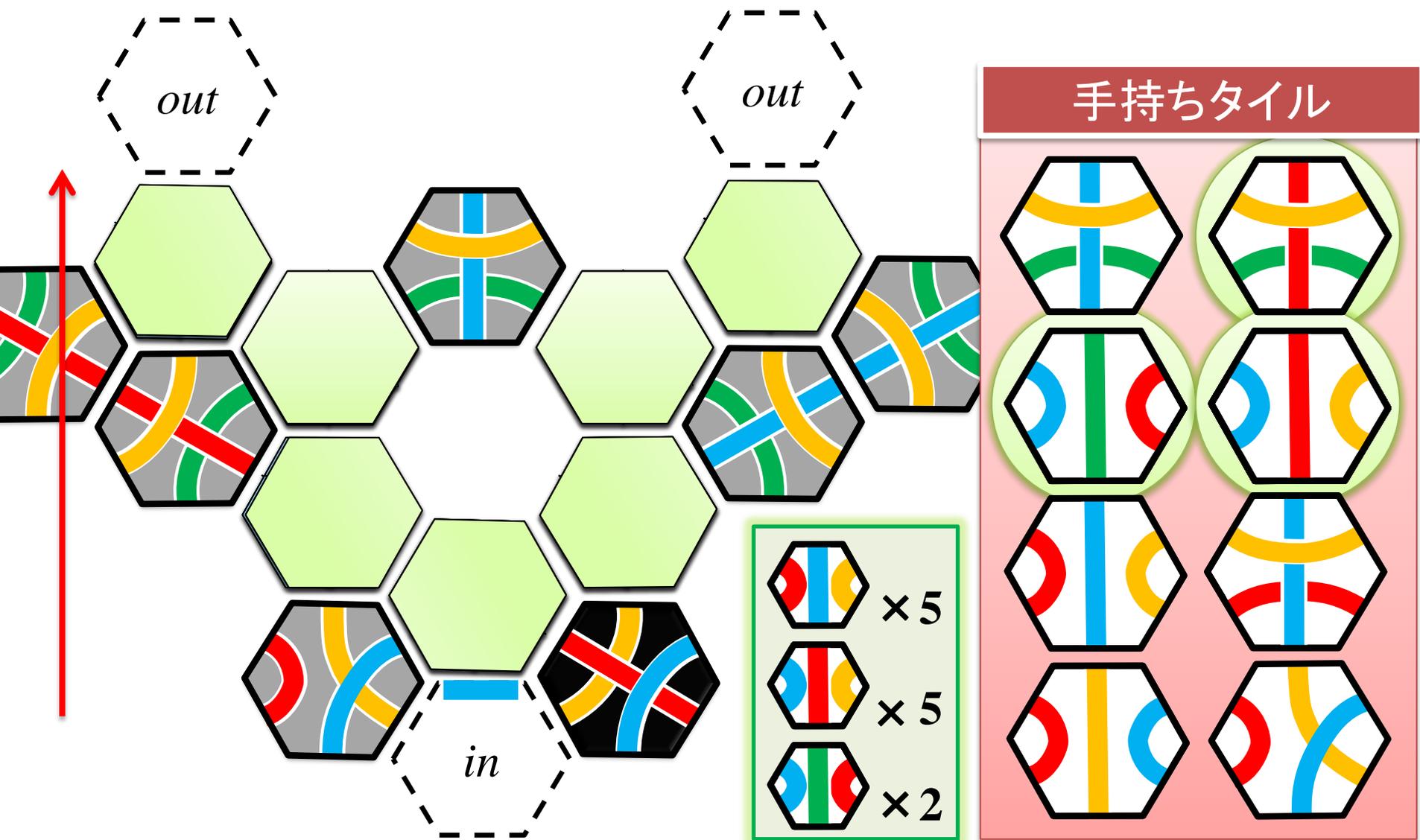


NOT部(偽の場合)

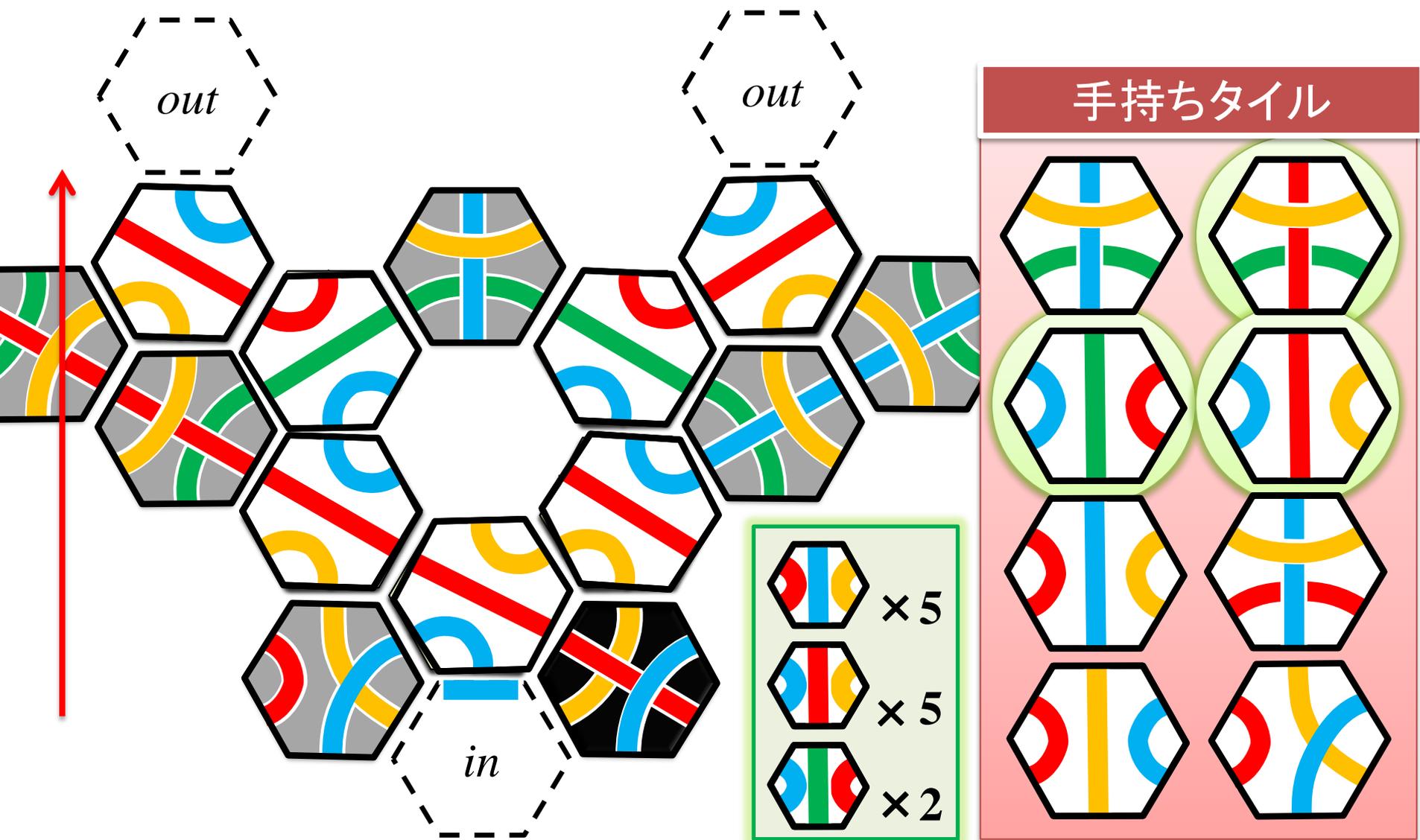


手持ちタイル

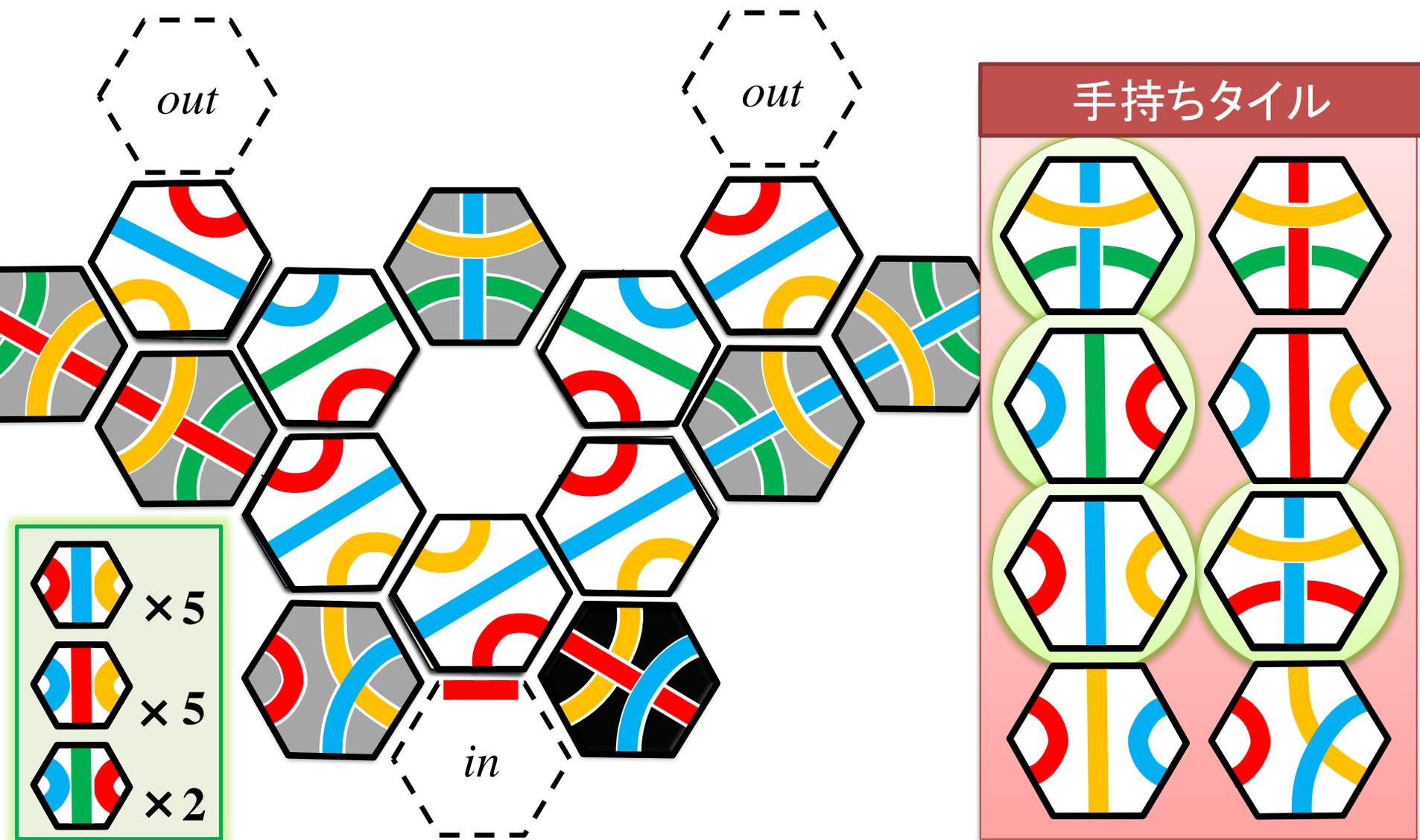
COPY部 (真の場合)



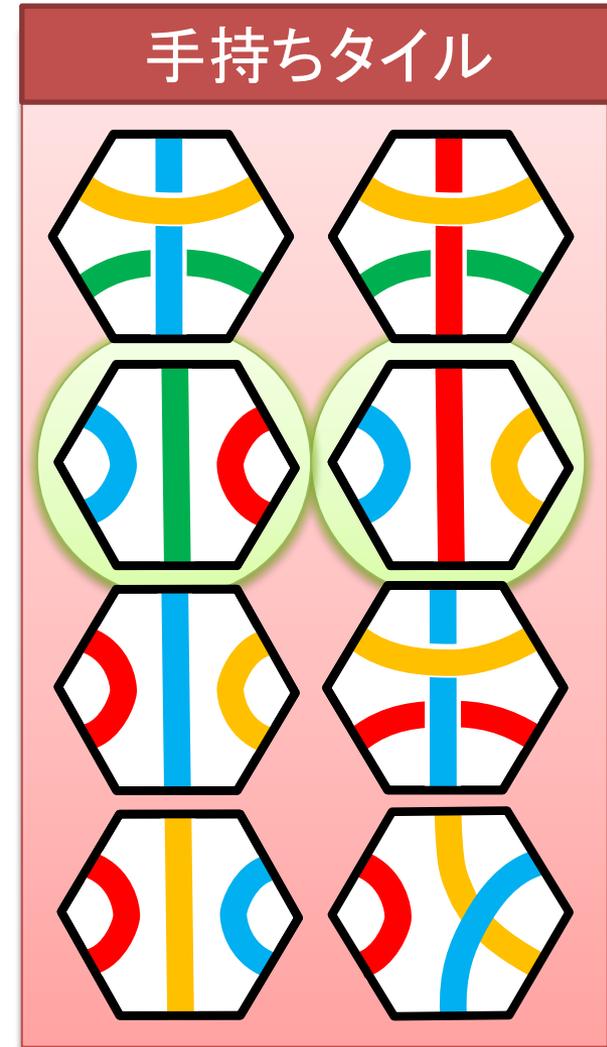
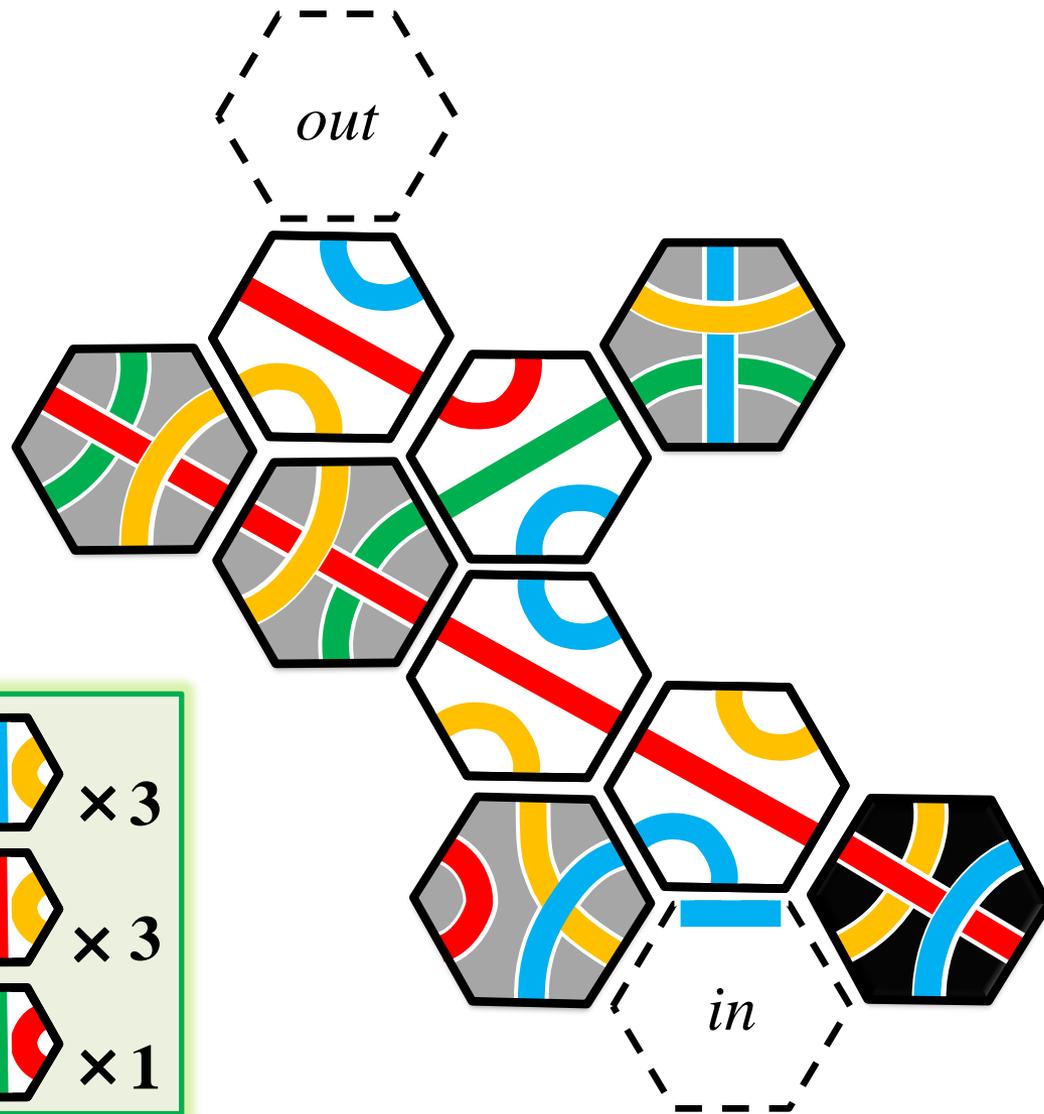
COPY部(真の場合)



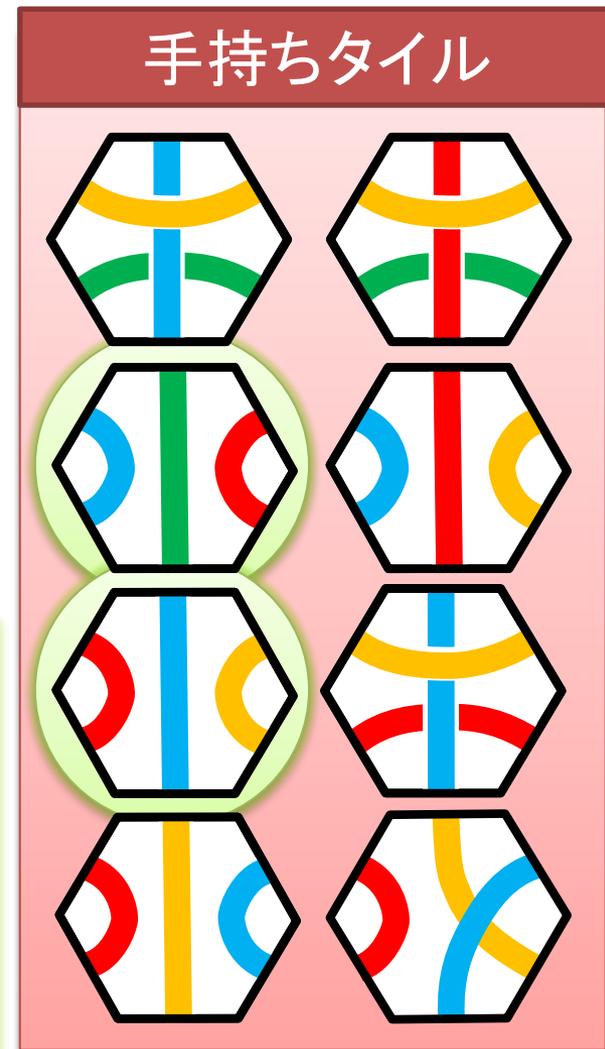
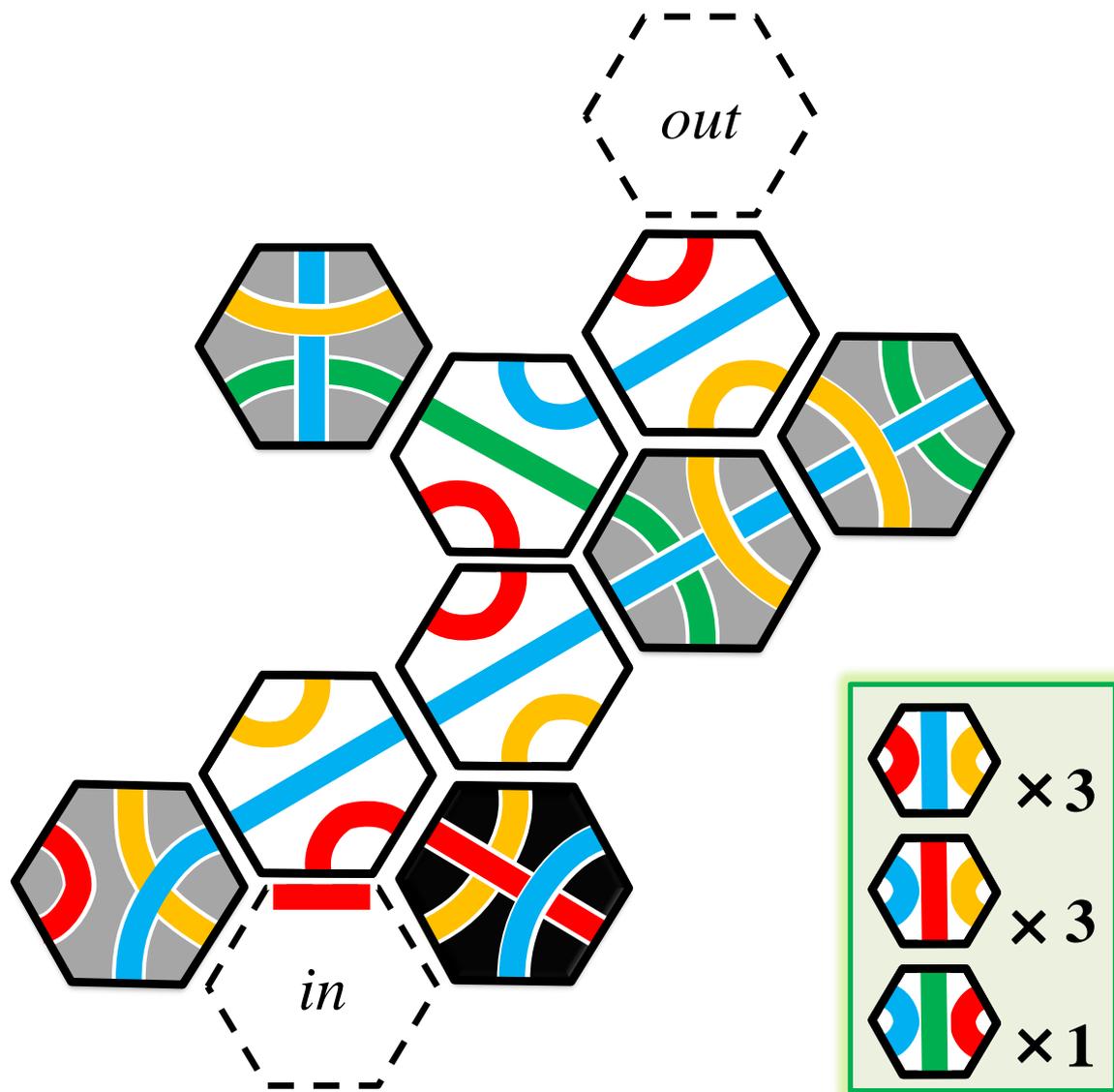
COPY部(偽の場合)



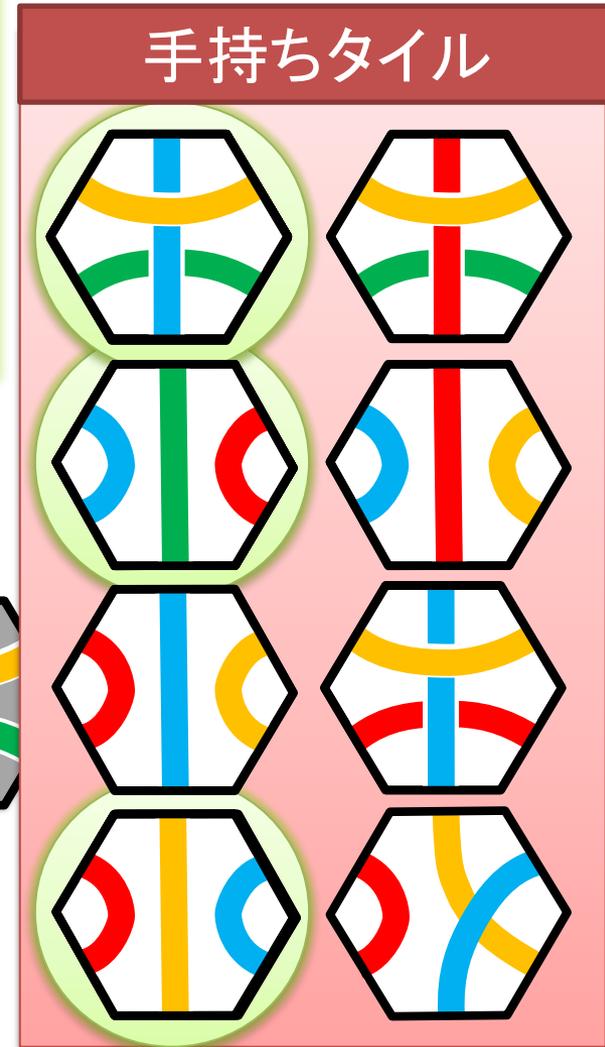
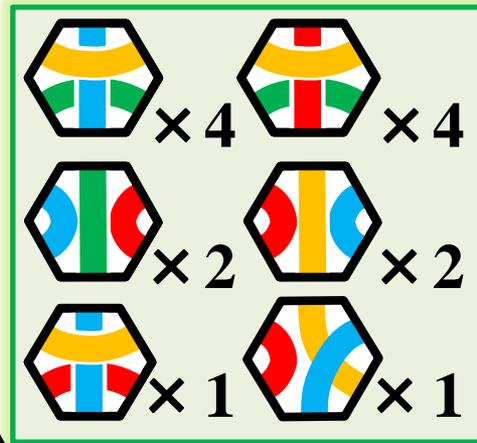
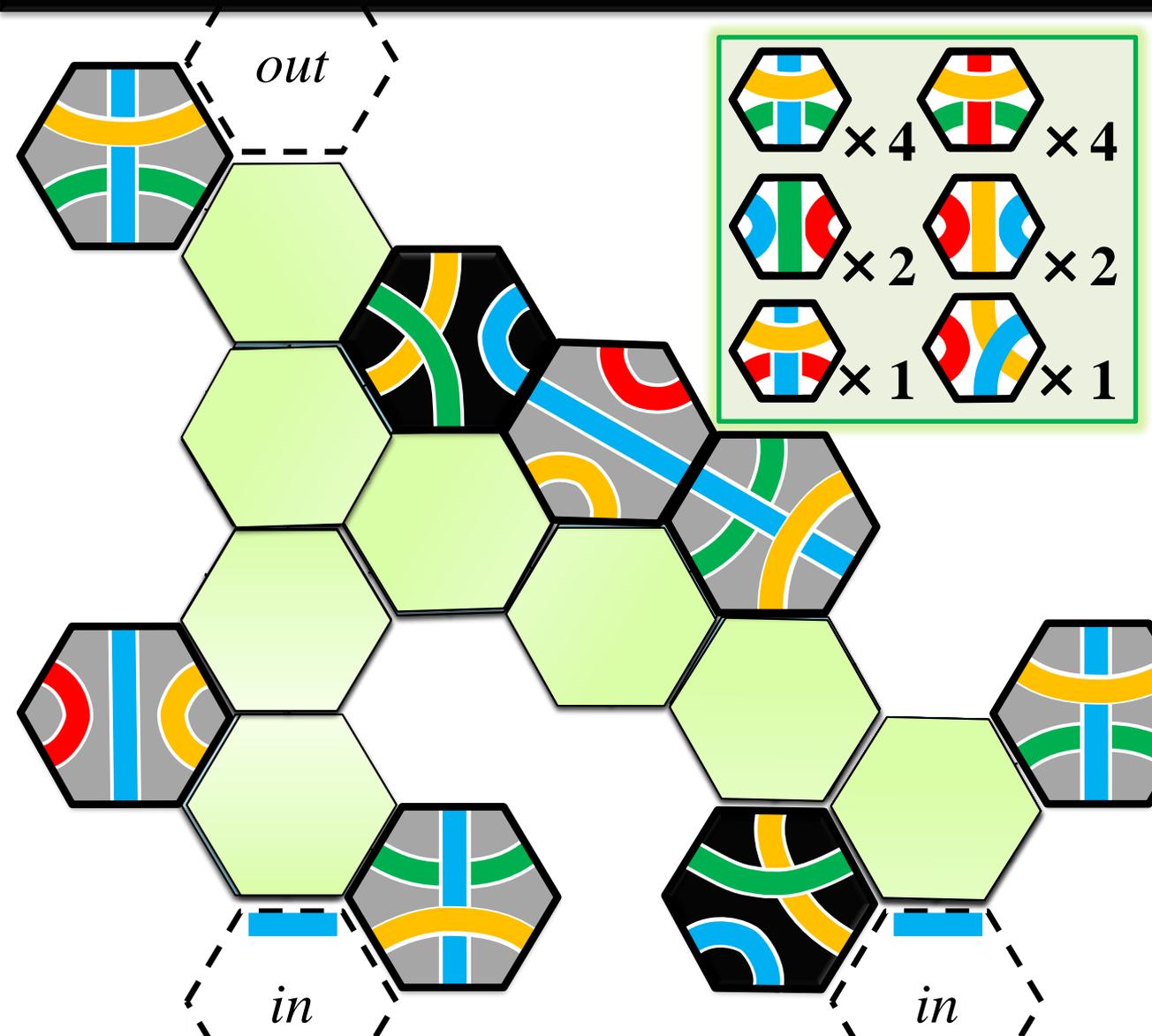
調整部 (真の場合)



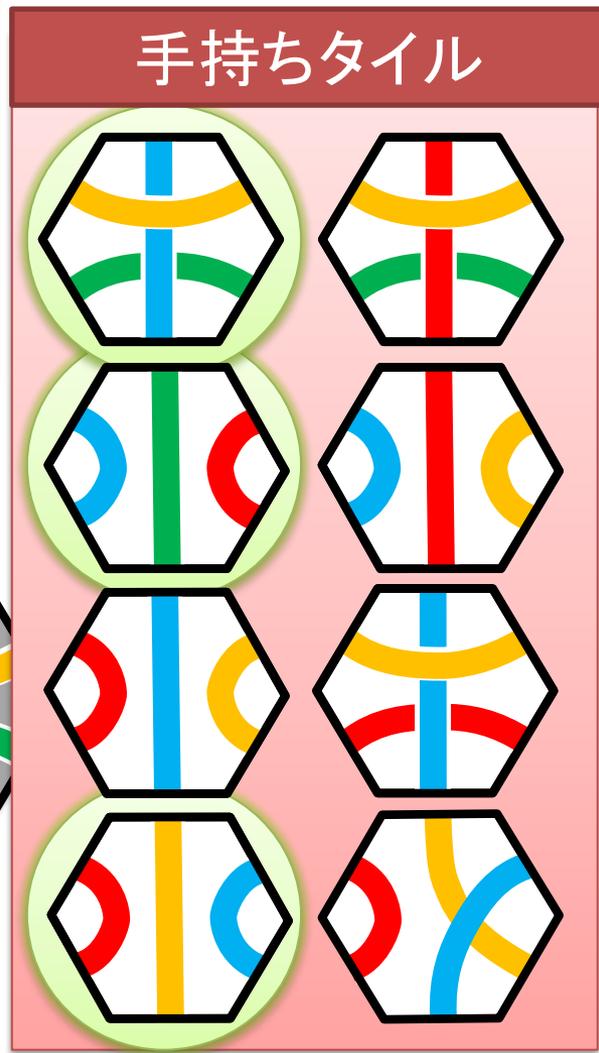
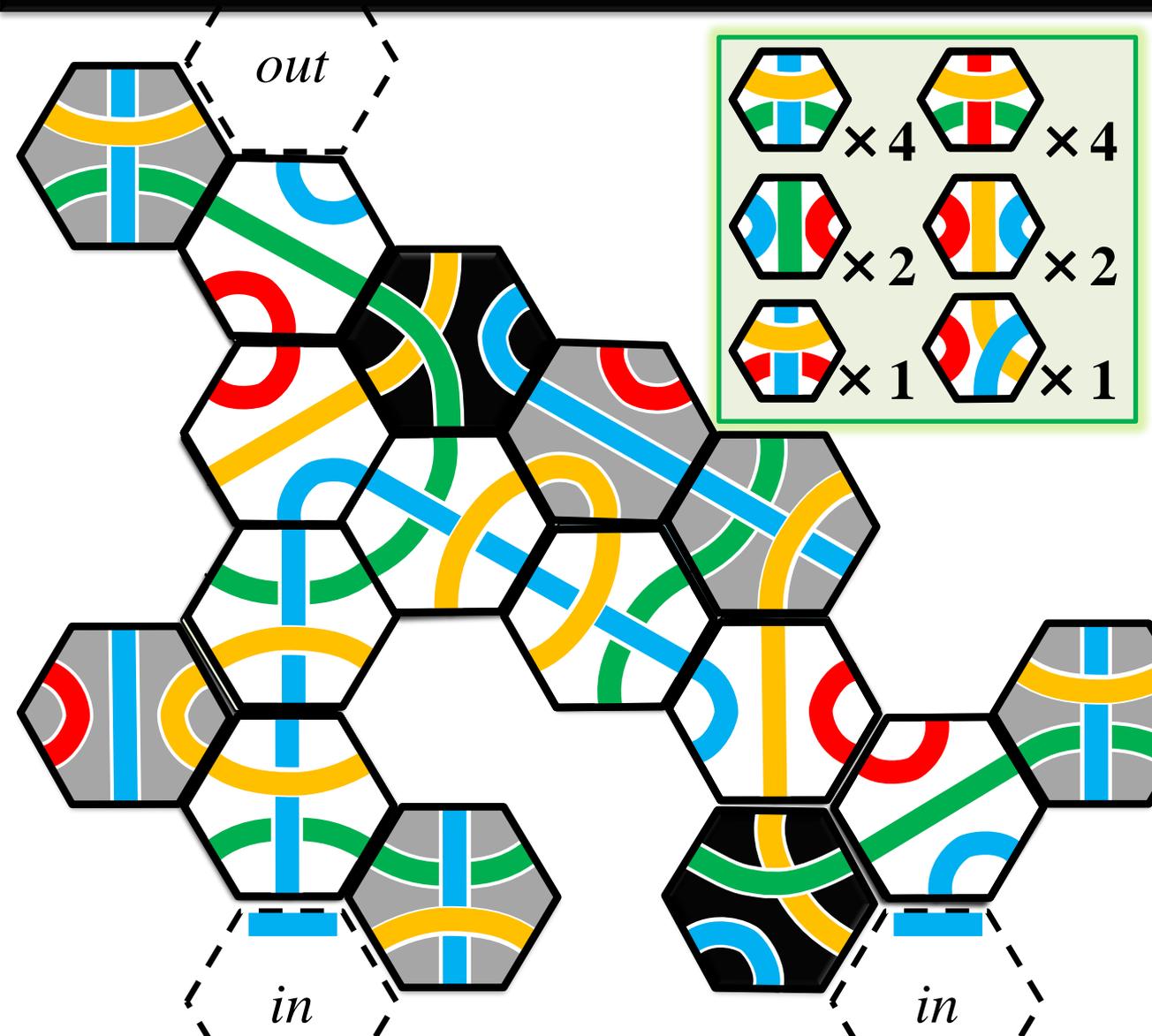
COPY部(偽の場合)



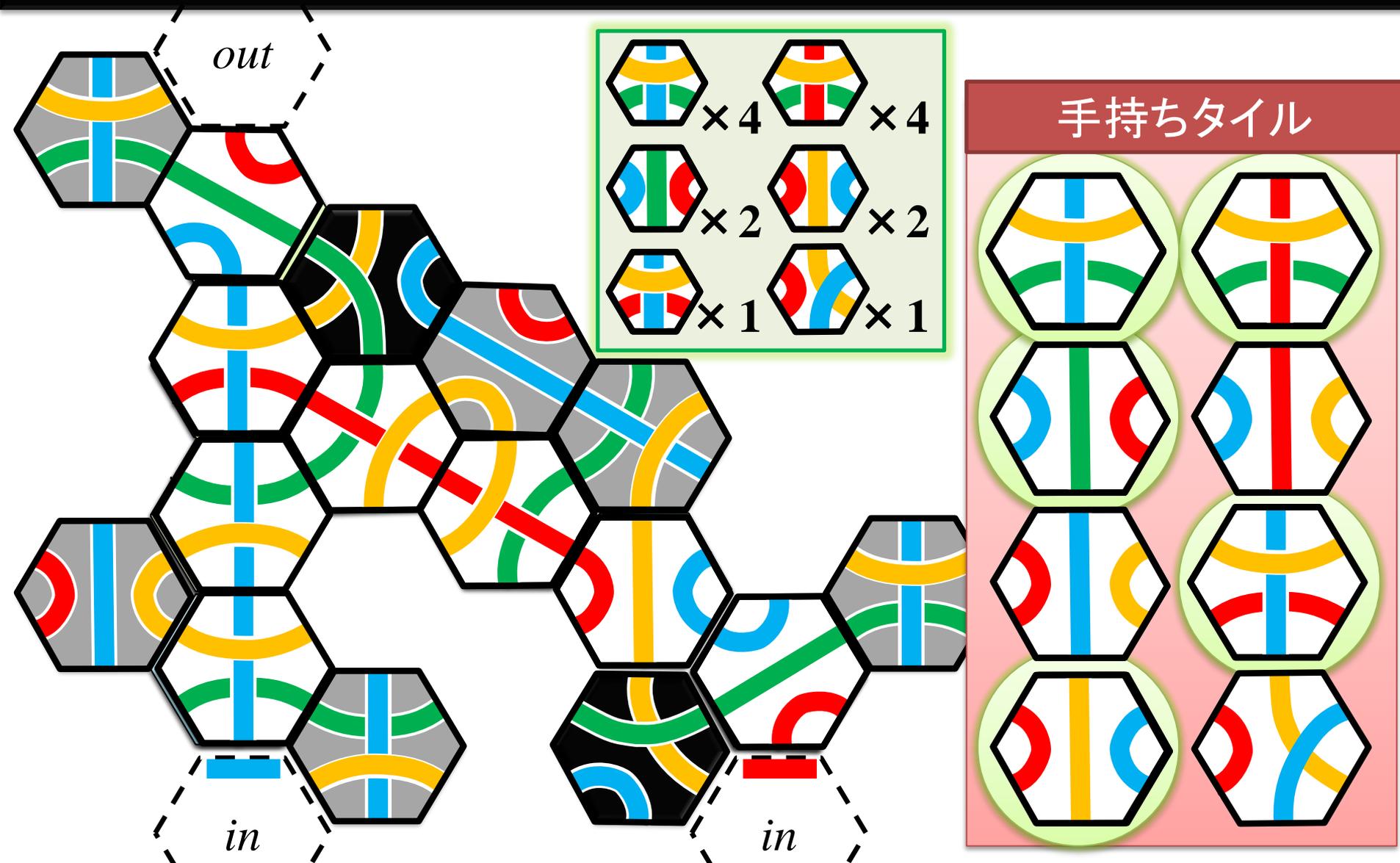
AND部



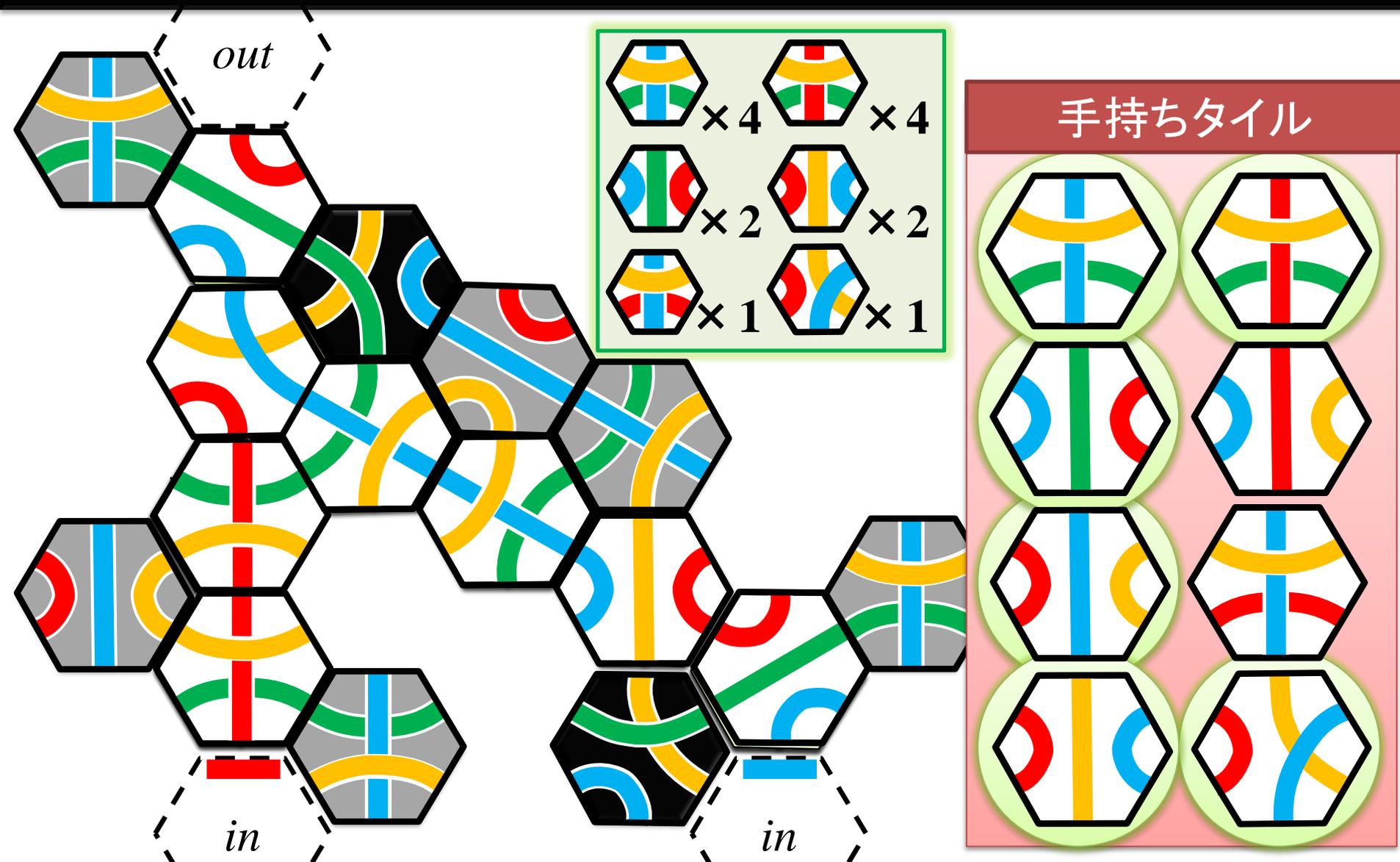
AND部(真・真の場合)



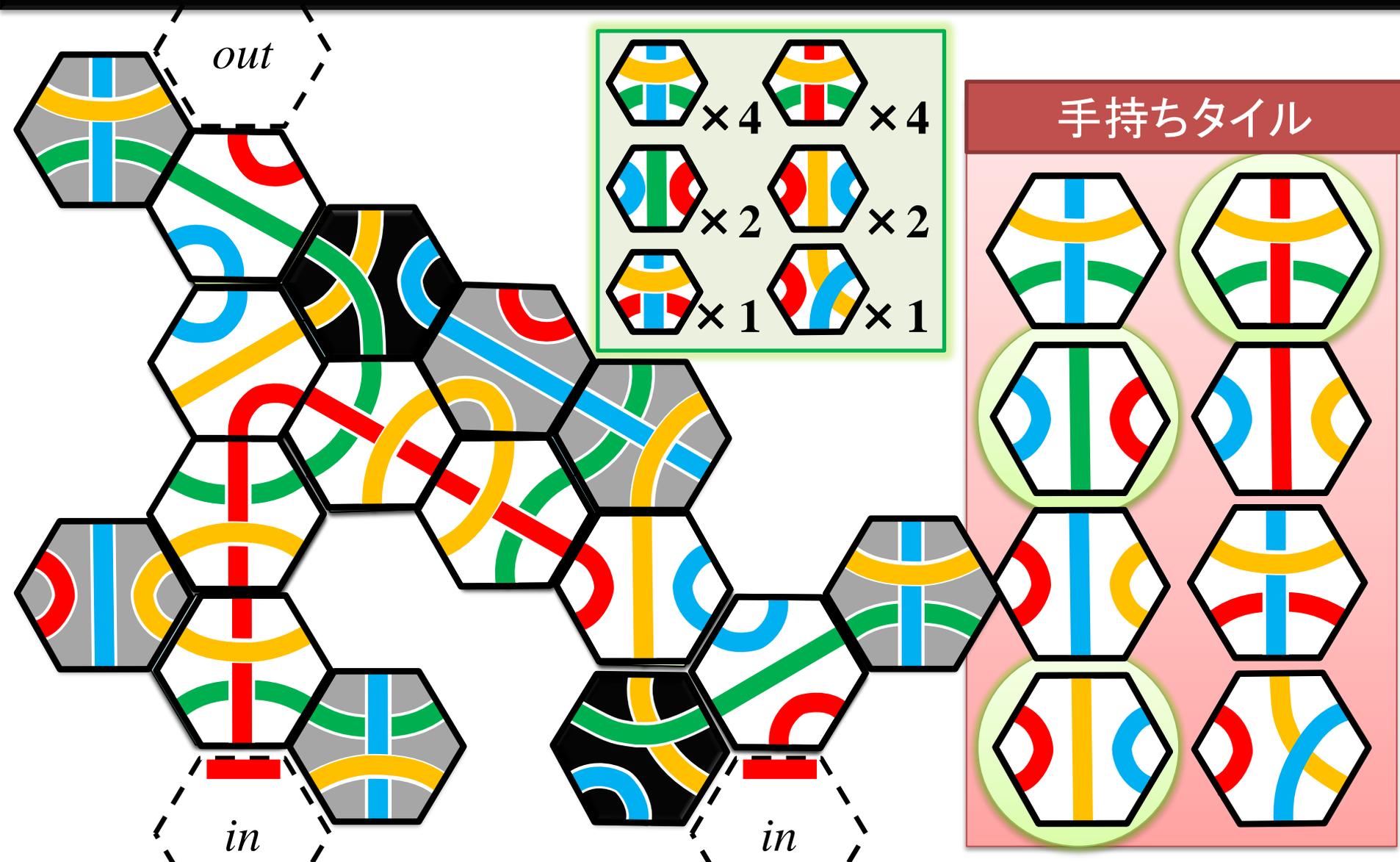
AND部(偽・真の場合)



AND部(真・偽の場合)



AND部(偽・偽の場合)

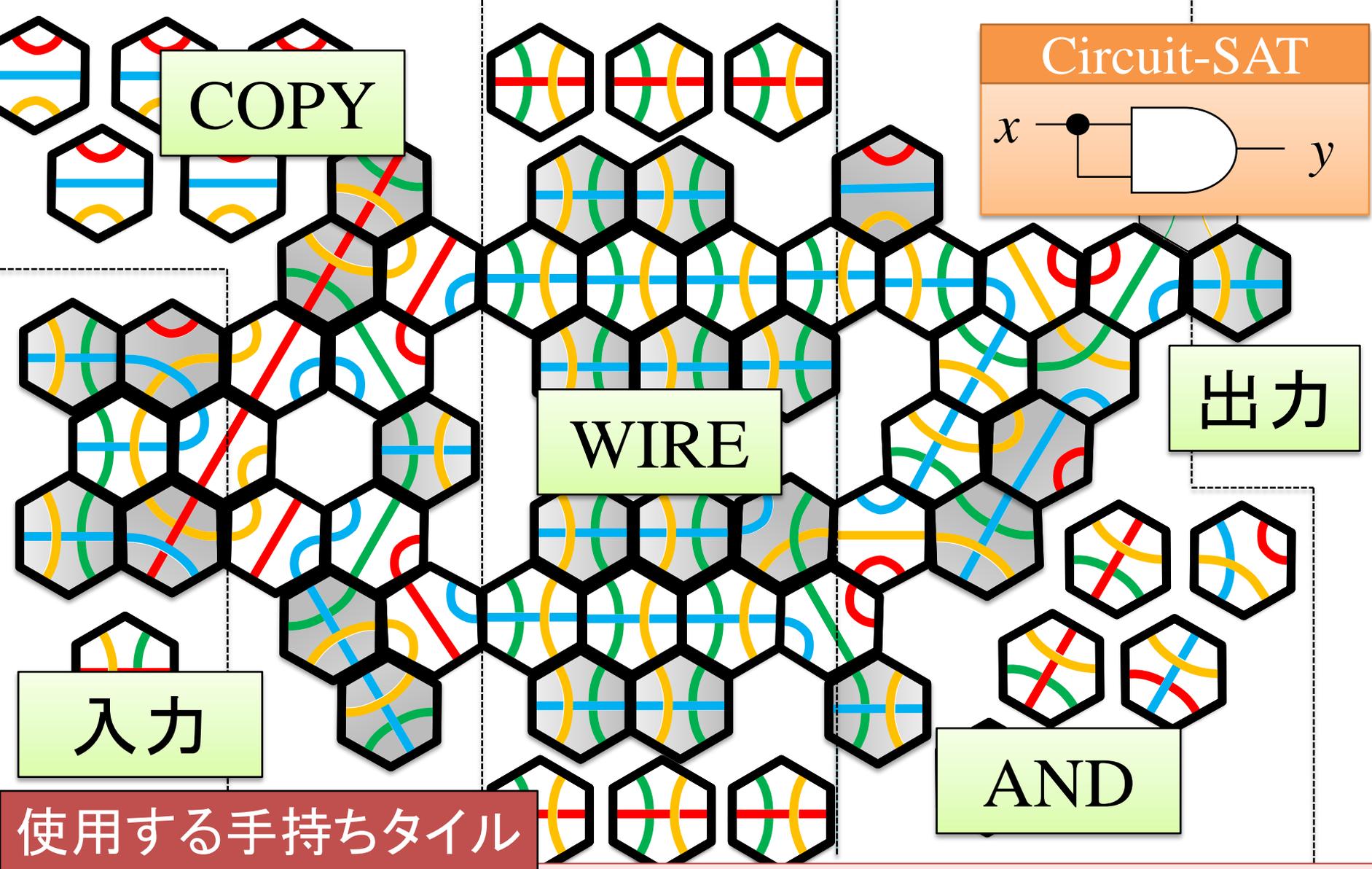


各部品で使用する手持ちタイル

WIRE部	●	●		▲						
入力部	●	●								
NOT部			●							
COPY部			●	▲	▲	●	●			
調整部			●	▲	▲	●	●			
AND部	●	●	●	●	●			●	●	●

●・・・その部品で使用するタイル

▲・・・AND部の構成で使用しない場合に配置できるタイル

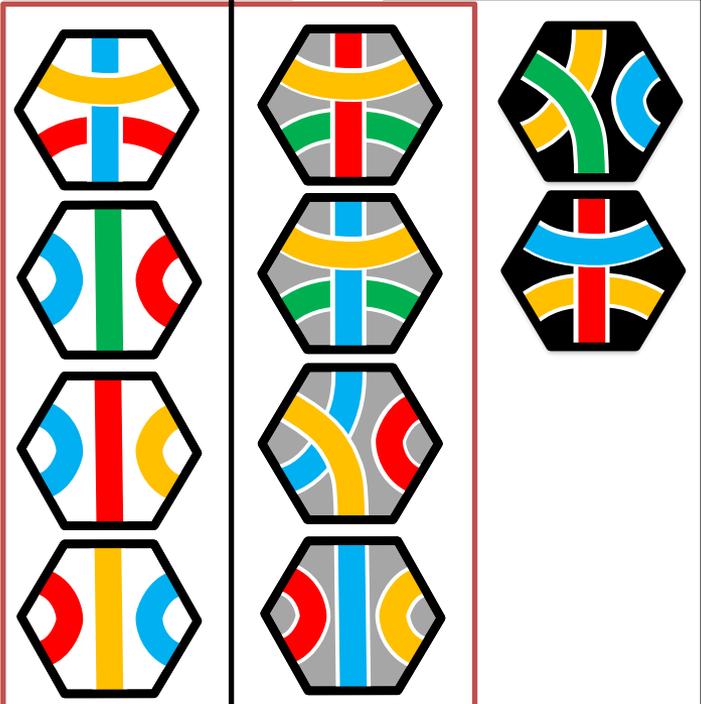


まとめ

3種の路・10種の
タイルに制限した場合

手持タイル

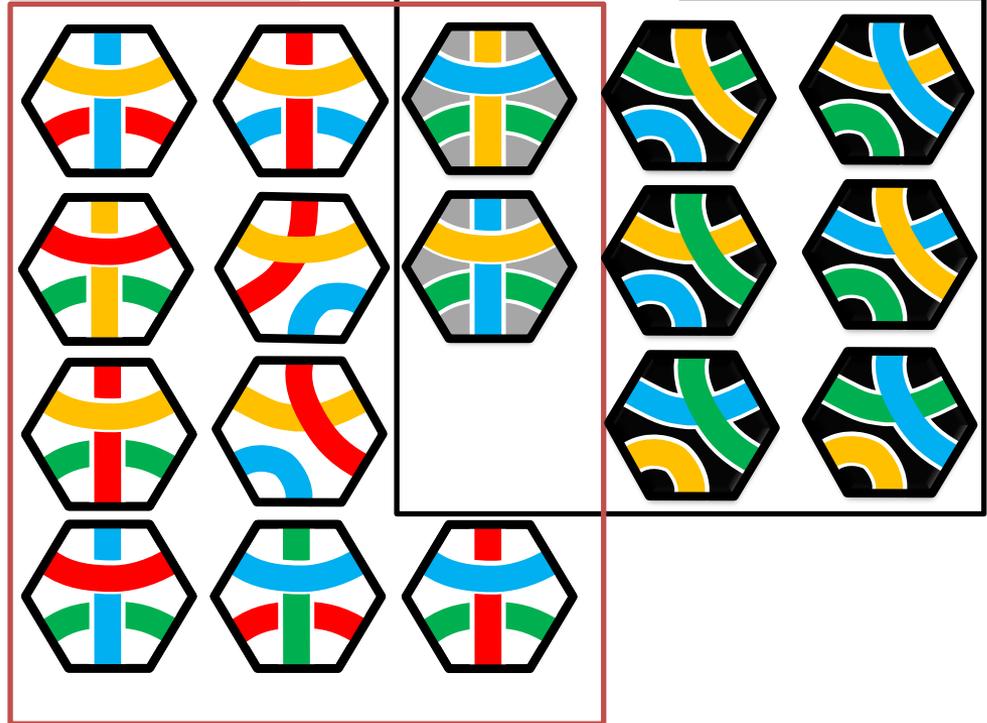
固定タイル



2種の路・17種の
タイルに制限した場合

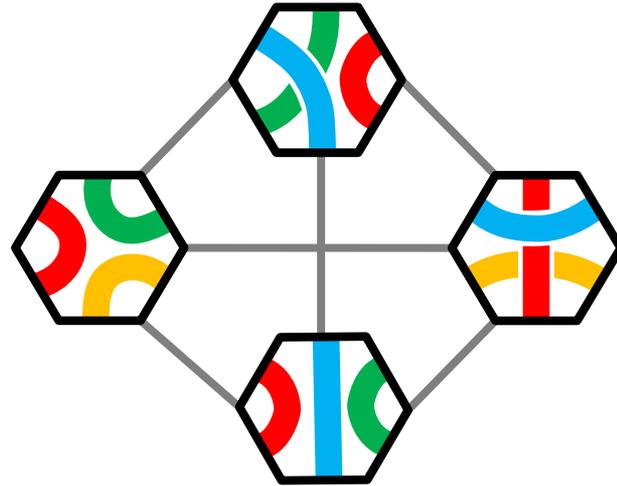
手持タイル

固定タイル



今後の課題

他のタイルの組み合わせ



さらにタイルの枚数・種類を削減

Tantrix DiscoveryのNP完全性の証明