„Combination of Speed-Up Techniques“

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Single Techniques

Existing speed-up techniques can be classified into two types:

goal directed: the search is pushed into the direction of the target, other paths are explored later or even pruned
↪ *exploitation of (usually) geometrical relations*
(A*, ALT, ArcFlags, ...)

hierarchical: graphs are organized in levels; a search tries to climb the hierarchy as high as possible and explores paths only on the reached level
↪ *utilization of inherent structural hierarchies*
(Reach, Highway Hierarchies, Contraction Hierarchies, Transit Node Routing, ...)

Technically, *bidirectional search* is also a speed-up technique.

Combination of Techniques

Different speed-up techniques exploit different properties of the graph. Combining them can improve the performance.

goals:

- increasing query speed-ups
- faster preprocessing
- requiring less additional memory

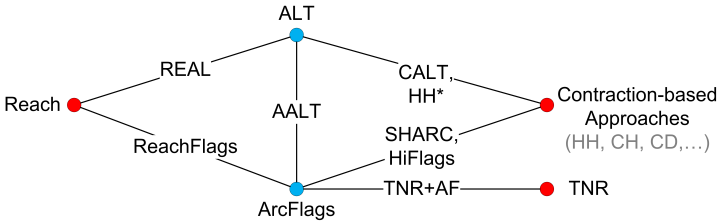
strategies for combining techniques:

- taking advantage of the pruning information to reduce the search space and of the directional information to advance the search of both techniques in each step
  ↪ highest query speed-ups
  ↪ preprocessing times and memory overhead add up
- performing a query with multiple phases, using different single speed-up techniques or combinations in each phase
  ↪ tradeoff between speed-up and overhead
- using less powerful variants of the individual techniques (i.e. fewer landmarks, less regions, ...):
  ↪ reduce preprocessing times and memory overhead
  ↪ retain query performance
- utilizing knowledge gained by the preprocessing step of one technique to improve the preprocessing of the other (i.e. selecting landmarks from nodes with a high level)

combining goal-direction & hierarchies

- hierarchical techniques are used as basis
- goal-direction can be added for the whole graph or only for the higher hierarchy levels (↪ *core-based routing*)
- *pitfalls of core-based routing:*
  required auxiliary information might not be available for source and target nodes (i.e. regions, landmark distances)
  ↪ information has to be approximated

Outline of Recent Combinations



blue: goal-directed techniques, red: hierarchical methods

Several Results

Measurement results of several speed-up techniques on the road network of Western Europe with a travel times metrik:

	Europe – travel times			
	— Prepro —		— Query —	
	[min]	[B/n]	settled	[ms]
Simple Techniques				
Plain Dijkstra (D)	0	0	$9 \cdot 10^6$	5 102.43
Bidirectional Dijkstra (BD)	0	0	$5 \cdot 10^6$	2 605.03
Hierarchical Techniques				
Contracted Dijkstra (CD)	11	4.6	151 698	183.90
Reach - Goldberg	83	17	4 643	3.47
Reach - Delling	70	21	7 387	6.24
Highway Hierarchies (HH)	13	48	709	0.61
Highway Node Routing (HNR)	15	2.4	981	0.85
Contraction Hierarchies (CH)	30	-2.7	368	0.16
Transit Node Routing (TNR)	112	204	n/a	0.0034
Goal-Directed Techniques				
ALT (16 avoid landmarks)	13	70	82 348	160.40
ALT (16 metis landmarks)	83	128	76 621	50.80
ALT (64 avoid landmarks)	92	512	26 630	18.40
ArcFlags - Hilger (1000 regions)	2 156	25	1 593	1.10
ArcFlags - Delling (128 regions)	11 789	81	2 764	0.80
Combinations				
REAL	141	36	679	1.11
Highway Hierarchies* (HH*)	14	72	511	0.49
SHARC	192	20	145	0.091
TNR + ArcFlags	229	321	n/a	0.0019
AALT (economical)	2 551	140	4 932	2.82
AALT (generous)	11 887	593	1 613	0.85
CALT (16 metis landmarks)	16	8	2 878	4.60
CALT (64 avoid landmarks)	14	20	1 394	2.40
ReachFlags (economical)	107	25	2 797	2.24
ReachFlags (generous)	229	30	1 168	0.76
HiFlags (economical)	32	0.0	86	0.064
HiFlags (generous)	99	12.0	43	0.028

listed values:
preprocessing: duration, memory overhead per node
query: average number of settled nodes, average running time

Summary

- most techniques are simple combinations (*bidirectional*)
- combining *goal-direction* and *hierarchies* most promising
- applying goal-direction only on *higher levels* is sufficient