Population–based anamorphosis maps for railway radial networks

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Abstract

The Spanish railway network is radial but very complex to operate, because two different track gauges, five signalling systems and two electrification systems coexist. Therefore, how to go on developing the high speed network and which are the best routes for trains are complicated questions. We are developing, in cooperation with the Spanish Railway Foundation, software packages that can be aids to decision making in these two issues. Yet one more step in this direction is presented here.

Keywords
Radial railway networks, Anamorphosis maps, Isochrone circle maps, Computer algebra systems

1 Introduction

The Spanish railway network is radial but very complex to operate, because:

- two different track gauges coexist: the so called *Iberian* gauge ($1667mm$) and the *international gauge* ($1435mm$) (used in the high speed network),
- two electrification systems have been used (3000 V DC, 25000 V AC) and, finally,
- there are different signalling systems (ASFA, ASFA 200, LZB, EBICAB, ERTMS).

The shape of the network is not due to a katabasis or anabasis of the whole Spanish society, but to the location of Madrid (the biggest city and capital) in the centre of the country and the location of the rest of big cities in the periphery. In 2013 the fares have been lowered and different discounts (for instance in low demand periods) are offered in order to attract more travelers and to increase the fraction of population using the high-speed trains.

Regarding the two gauges, there are gauge changeovers at several points, so that both subnetworks are connected. A subset of the rolling stock is dual gauge. Regarding electrification and signalling systems, many locomotives and multiple units can read different signalling systems, are multi-voltage. Even hybrid rolling stock has been developed (730 series).

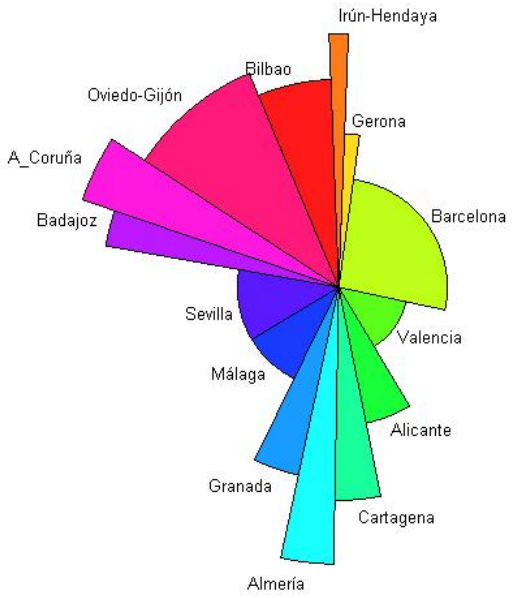
The high speed network has grown very quickly, and only China has nowadays a longer high speed railway network. All new lines have been built with double track and top technologies ($\geq 300km/h$ track design, *ERTMS* traffic management system, $25000KV$ AC electrification, etc.).

The growth of the network has been supported by the different governments and has only been slowed down due to the economical crisis.

Nevertheless, how to go on developing the high speed network and which are the best routes for trains are complicated questions. We are developing, in cooperation with the *Spanish Railway Foundation*, software packages that can be aids to decision making in these two issues. We have followed two lines:

- We have developed (within the frame of two research projects signed between the *Spanish Railways Foundation* and the *Universidad Complutense de Madrid* and the *Universidad Politécnica de Madrid*) a computer package that is able to calculate precise timings, consumptions, costs, emissions, best routes, etc., for each piece of *Renfe*'s (main railway operator) rolling stock running on *Adif*'s (infrastructure company) lines [1].

- We have also developed what we have called *isochrone circle graphs* and a *geometric index* for radial railway networks improvement estimation [2]. *Isochrone circle graphs* were inspired by pie charts (also known as circle graphs), polar area diagrams (similar to usual pie charts, but sectors are equal angles and their area is adjusted changing their radii instead of their amplitude) and anamorphosis maps (also known as central point cartograms or distance cartograms; where the geometry of the country or region is distorted according to the time that it takes to travel to different peripheral destinations from a central origin). An *isochrone circle graph* corresponding to Spain in 2013 (centred at Madrid) can be found in the figure below.



We have followed two approaches to compute and draw *isochrone circle graphs*:

  - The first approach [2] was illustrated with a sketch constructed with a Dynamic Geometry System and used sliders to change the input parameters (timing to each peripheral destination and population of these destinations). It was very comfortable to use, but the number of destinations considered was somehow fixed (changing it required to construct a complete new sketch).
  - In the second approach we designed and implemented a complete new package in the CAS *Maple* that takes as input the lists of destinations, best timings and populations and builds the corresponding *isochrone circle graphs* and performs all the corresponding calculations [3]. This approach has yet another advantage: symbolic computations can be performed, and therefore parameters can be introduced in the computations.

An improved version of [3] will be presented here. It has to be emphasized that now a population–based version of an anamorphosis map can be drawn or superimposed to the *isochrone circle graph*.

References

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