

Survey of Sombor-Type Degree-Based Topological Indices

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Abstract

The Sombor index is a graph invariant, defined as the sum over all edges uv (pairs of adjacent vertices u and v) of the term $\sqrt{d(u)^2 + d(v)^2}$, where $d(u)$ denotes the degree of the vertex u . It was invented in 2021. Since then, remarkably many of its variants were proposed and considered in the literature. This survey provides an exhaustive list of these variants, restricted to those that depend solely on vertex degree.

1 Introduction

In the formulas given in this survey, we use the following notation. By G is denoted a simple graph with vertex set $V(G)$ and edge set $E(G)$, with $n = |V(G)|$ vertices and $m = |E(G)|$ edges. The edge connecting the vertices u and v is denoted by uv . The degree of the vertex $u \in V(G)$ is denoted by $d(u)$. The maximal and minimal vertex degree of G are Δ and δ , respectively. The degree of the edge $e = uv \in E(G)$ is $d(e) = d(u) + d(v) - 2$.

In the current literature, a large class of graph invariants is being considered, referred to as “vertex-degree-based” (VDB) or “bond incident

degree" (BID) topological indices, defined as

$$\Theta = \Theta(G) = \sum_{uv \in E(G)} F(d(u), d(v)) \quad (1)$$

where $F(x, y)$ is some properly chosen function, satisfying the condition $F(x, y) = F(y, x)$.

If $F(x, y) = \sqrt{x^2 + y^2}$, i.e., if

$$\sum_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2}$$

then the respective graph invariant is called *Sombor index*, invented in 2021 [13].

Already in the first paper on this matter [13], two variants of the Sombor index were proposed, namely those pertaining to

$$F(x, y) = \sqrt{(x-1)^2 + (y-1)^2}$$

and

$$F(x, y) = \sqrt{(x-2m/n)^2 + (y-2m/n)^2}.$$

Since then, a remarkably large number of other Sombor-type indices were introduced and studied. In this survey, we give a list of such invariants, together with references to their origin.

Our list of Sombor-type indices will include only those depending on vertex degrees. In addition to these, there exist additional Sombor-type graph invariants, depending on other graph parameters. Their general form is

$$\Gamma = \Gamma(G) = \sum_{uv \in E(G)} \sqrt{\gamma(u)^2 + \gamma(v)^2}$$

where $\gamma(u)$ is some graph parameter associated with the vertex $u \in V(G)$. Thus, for instance:

- if $\gamma(u)$ is the eccentricity of the vertex u (maximum distance between u and the other vertices of G), then Γ is the eccentric Sombor index [20, 23];

- if $\gamma(u)$ is the status of the vertex u (sum of distances between u and the other vertices of G), then Γ is the status Sombor index [33];
- if $\gamma(u)$ is the open neighborhood of the vertex u (sum of degrees of vertices adjacent to u), then Γ is the neighborhood Sombor index [5];
- if $\gamma(u)$ is the stress of the vertex u (number of shortest paths in G , going through u), then Γ is the stress Sombor index [57];
- if $\gamma(u)$ is the number of vertices lying closer to u than to v , then Γ is the Szeged Sombor index [2];
- if $\gamma(u)$ is the number of uphill (resp. downhill) paths starting at vertex u , then Γ is the uphill Sombor (resp. downhill Sombor) index [39, 40].

Topological indices of this kind are not included in the list that follows.

2 Degree-Based Sombor Indices

Here are presented the Sombor-type indices, known to the author in February 2026. Before listing them, it should be mentioned that if Θ is a VDB topological index defined via Eq. (1), then

$$\sum_{uv \in E(G)} F(d(u) - 1, d(v) - 1)$$

is said to be the *reduced Θ index*,

$$\sum_{uv \in E(G)} \frac{1}{F(d(u), d(v))}$$

is said to be the *modified Θ index*,

$$\sum_{uv \in E(G)} e^{F(d(u), d(v))}$$

is said to be the *exponential* Θ *index*, and

$$\sum_{\substack{uv \notin E(G) \\ u \neq v}} F(d(u), d(v))$$

is said to be the *coindex* of Θ .

This terminology is applicable also to Sombor-type indices.

2.1 List of Sombor-Type Indices

- Sombor index [13]

$$\sum_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2}$$

- reduced Sombor index [13]

$$\sum_{uv \in E(G)} \sqrt{[d(u) - 1]^2 + [d(v) - 1]^2}$$

- generalized reduced Sombor index; $p =$ integer or real number [12]

$$\sum_{uv \in E(G)} \sqrt{[d(u) - p]^2 + [d(v) - p]^2}$$

- increased Sombor index [9]

$$\sum_{uv \in E(G)} \sqrt{[d(u) + 1]^2 + [d(v) + 1]^2}$$

- average Sombor index [13]

$$\sum_{uv \in E(G)} \sqrt{\left[d(u) - \frac{2m}{n} \right]^2 + \left[d(v) - \frac{2m}{n} \right]^2}$$

- modified Sombor index [42]

$$\sum_{uv \in E(G)} \frac{1}{\sqrt{d(u)^2 + d(v)^2}}$$

- Gourava Sombor index [32]

$$\sum_{uv \in E(G)} \sqrt{[d(u) + d(v)]^2 + [d(u) d(v)]^2}$$

- reduced Gourava Sombor index [32]

$$\sum_{uv \in E(G)} \sqrt{[(d(u) - 1) + (d(v) - 1)]^2 + [(d(u) - 1)(d(v) - 1)]^2}$$

- Gourava Sombor exponential [32]

$$\sum_{uv \in E(G)} e^{\sqrt{[d(u)+d(v)]^2+[d(u) d(v)]^2}}$$

- first Banhatti–Sombor index [46]

$$\sum_{uv \in E(G)} \sqrt{\frac{1}{d(u)^2} + \frac{1}{d(v)^2}}$$

- reduced first Banhatti–Sombor index [24]

$$\sum_{uv \in E(G)} \sqrt{\frac{1}{[d(u) - 1]^2} + \frac{1}{[d(v) - 1]^2}}$$

- second Banhatti–Sombor index [24]

$$\sum_{uv \in E(G)} \left[\sqrt{\frac{1}{d(u)^2} + \frac{1}{d(v)^2}} \right]^{-1}$$

- reduced second Banhatti–Sombor index [24]

$$\sum_{uv \in E(G)} \left[\sqrt{\frac{1}{[d(u)-1]^2} + \frac{1}{[d(v)-1]^2}} \right]^{-1}$$

- p -Sombor index; $p =$ integer or real number [58]

$$\sum_{uv \in E(G)} [d(u)^p + d(v)^p]^{1/p}$$

- inf-Sombor index (or infinite Sombor index) [22]

$$\lim_{p \rightarrow \infty} \sum_{uv \in E(G)} [d(u)^p + d(v)^p]^{1/p} = \sum_{uv \in E(G)} \max\{d(u), d(v)\}$$

- mean Sombor index [48]

$$\sum_{uv \in E(G)} \left[\frac{d(u)^p + d(v)^p}{2} \right]^{1/p}$$

- Sombor coindex [7]

$$\sum_{\substack{uv \notin E(G) \\ u \neq v}} \sqrt{d(u)^2 + d(v)^2}$$

- general Sombor index; $\alpha =$ real number [8]

$$\sum_{uv \in E(G)} [d(u)^2 + d(v)^2]^{\alpha/2}$$

- general Sombor index; $\alpha, \beta =$ real numbers [55]

$$\sum_{uv \in E(G)} [d(u)^\alpha + d(v)^\alpha]^\beta$$

- δ -Sombor index [25]

$$\sum_{uv \in E(G)} \sqrt{[d(u) - \delta + 1]^2 + [d(v) - \delta + 1]^2}$$

- δ -Banhatti-Sombor index [27]

$$\sum_{uv \in E(G)} \sqrt{\frac{1}{[d(u) - \delta + 1]^2} + \frac{1}{[d(v) - \delta + 1]^2}}$$

- multiplicative Sombor index [26]

$$\prod_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2}$$

- multiplicative reduced Sombor index [26]

$$\prod_{uv \in E(G)} \sqrt{[d(u) - 1]^2 + [d(v) - 1]^2}$$

- multiplicative modified Sombor index [26]

$$\prod_{uv \in E(G)} \frac{1}{\sqrt{d(u)^2 + d(v)^2}}$$

- multiplicative reduced modified Sombor index [26]

$$\prod_{uv \in E(G)} \frac{1}{\sqrt{[d(u) - 1]^2 + [d(v) - 1]^2}}$$

- multiplicative first Bhanhatti-Sombor index [27]

$$\prod_{uv \in E(G)} \sqrt{\frac{1}{d(u)^2} + \frac{1}{d(v)^2}}$$

- multiplicative reduced first Banhatti–Sombor index [27]

$$\prod_{uv \in E(G)} \sqrt{\frac{1}{[d(u) - 1]^2} + \frac{1}{[d(v) - 1]^2}}$$

- multiplicative δ -Banhatti–Sombor index [27]

$$\prod_{uv \in E(G)} \sqrt{\frac{1}{[d(u) - \delta + 1]^2} + \frac{1}{[d(v) - \delta + 1]^2}}$$

- irregularity Sombor index [28]

$$\sum_{uv \in E(G)} \sqrt{|d(u)^2 - d(v)^2|}$$

In [11], called “first irregularity Sombor index”.

- reverse Sombor index [59]

$$\sum_{uv \in E(G)} \sqrt{[\Delta + 1 - d(u)]^2 + [\Delta + 1 - d(v)]^2}$$

- Revan Sombor index [43]

$$\sum_{uv \in E(G)} \sqrt{[\Delta + \delta - d(u)]^2 + [\Delta + \delta - d(v)]^2}$$

- exponential Sombor index [25]

$$\sum_{uv \in E(G)} e^{\sqrt{d(u)^2 + d(v)^2}}$$

- exponential reduced Sombor index [61]

$$\sum_{uv \in E(G)} e^{\sqrt{[d(u) - 1]^2 + [d(v) - 1]^2}}$$

- KG-Sombor index [44]

$$\sum_{ue} \sqrt{d(u)^2 + d(e)^2} = \sum_{uv \in E(G)} \left[\sqrt{d(u)^2 + [d(u) + d(v) - 2]^2} + \sqrt{d(v)^2 + [d(u) + d(v) - 2]^2} \right]$$

- entire Sombor index [49]

$$\sum_{x,y} \sqrt{d(x)^2 + d(y)^2}$$

where $\{x, y\} \subseteq V(G) \cup E(G)$, such that x and y are adjacent or incident to each other.

- reformulated Sombor index [21]

$$\sum_{\substack{e, f \in E(G) \\ e \sim f}} \sqrt{d(e)^2 + d(f)^2}$$

where $e \sim f$ indicates incident edges. It coincides with the ordinary Sombor index of the line graph of G .

- nirmala index [29]

$$\sum_{uv \in E(G)} \sqrt{d(u) + d(v)}$$

- Dharwad index [30]; also called Yemen-Sombor index [62]

$$\sum_{uv \in E(G)} \sqrt{d(u)^3 + d(v)^3}$$

- F -Sombor index [34]

$$\sum_{uv \in E(G)} \sqrt{d(u)^4 + d(v)^4}$$

- temperature Sombor index [31]

$$\sum_{uv \in E(G)} \sqrt{\left(\frac{n}{n-d(u)}\right)^2 + \left(\frac{n}{n-d(v)}\right)^2}$$

- Sombor-index-like invariants [14]

$$SO_1 = \sum_{uv \in E(G)} \frac{1}{2} |d(u)^2 - d(v)^2|$$

$$SO_2 = \sum_{uv \in E(G)} \frac{|d(u)^2 - d(v)^2|}{|d(u)^2 + d(v)^2|}$$

$$SO_3 = \sum_{uv \in E(G)} \sqrt{2} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \pi$$

$$SO_4 = \sum_{uv \in E(G)} \frac{1}{2} \left(\frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \right)^2 \pi$$

$$SO_5 = \sum_{uv \in E(G)} \frac{2\sqrt{2} \beta_{uv} |d(u) - d(v)|}{2\beta_{uv} + \sqrt{2} |d(u) - d(v)|} \pi$$

$$SO_6 = \sum_{uv \in E(G)} \frac{\beta_{uv}^2 (d(u) - d(v))^2}{[2\beta_{uv} + \sqrt{2} |d(u) - d(v)|]^2} \pi$$

where

$$\beta_{uv} = \sqrt{d(u)^2 + d(v)^2 + \frac{1}{2} [d(u) - d(v)]^2}.$$

In [60], SO_2 is called “second Sombor index”.

- degree-ratio Sombor index [52]

$$\sum_{uv \in E(G)} \sqrt{\left(\frac{d(u)}{d(v)}\right)^2 + \left(\frac{d(v)}{d(u)}\right)^2}$$

- tangent Sombor index [53]

$$\sum_{uv \in E(G)} \frac{|d(u)^2 - d(v)^2|}{2d(u)d(v)}$$

- elliptic Sombor index [16]

$$\sum_{uv \in E(G)} [d(u) + d(v)] \sqrt{d(u)^2 + d(v)^2}$$

- modified elliptic Sombor index [35]

$$\sum_{uv \in E(G)} \frac{1}{[d(u) + d(v)] \sqrt{d(u)^2 + d(v)^2}}$$

- exponential modified elliptic Sombor index [35]

$$\sum_{uv \in E(G)} e^{1/[d(u)+d(v)]\sqrt{d(u)^2+d(v)^2}}$$

- multiplicative elliptic Sombor index [36]

$$\prod_{uv \in E(G)} [d(u) + d(v)] \sqrt{d(u)^2 + d(v)^2}$$

- multiplicative modified elliptic Sombor index [36]

$$\prod_{uv \in E(G)} \frac{1}{[d(u) + d(v)] \sqrt{d(u)^2 + d(v)^2}}$$

- general elliptic Sombor index; $\alpha =$ real number [55]

$$\sum_{uv \in E(G)} [d(u) + d(v)]^\alpha [d(u)^2 + d(v)^2]^{\alpha/2}$$

- reduced Sombor index [56]; renamed as diminished Sombor index [50]

$$\sum_{uv \in E(G)} \frac{\sqrt{d(u)^2 + d(v)^2}}{d_u + d_v}$$

- hyperbolic Sombor index [6]

$$\sum_{uv \in E(G)} \frac{\sqrt{d(u)^2 + d(v)^2}}{\min\{d_u, d_v\}}$$

- complementary diminished Sombor index [4]

$$\sum_{uv \in E(G)} \frac{\sqrt{d(u)^2 + d(v)^2}}{\max\{d_u, d_v\}}$$

- augmented Sombor index [10]

$$\sum_{uv \in E(G)} \sqrt{\frac{d(u)^2 + d(v)^2}{d(u) + d(v) - 2}}$$

- augmented Euler Sombor index [41]

$$\sum_{uv \in E(G)} \sqrt{\frac{d(u)^2 + d(v)^2 + d(u) d(v)}{d(u) + d(v) - 2}}$$

- reciprocal augmented Euler Sombor index [41]

$$\sum_{uv \in E(G)} \sqrt{\frac{d(u) + d(v) - 2}{d(u)^2 + d(v)^2 + d(u) d(v)}}$$

- Zagreb Sombor index [3]

$$\sum_{uv \in E(G)} d(u) d(v) \sqrt{d(u)^2 + d(v)^2}$$

- Euler-Sombor index [15]

$$\sum_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2 + d(u) d(v)}$$

- reduced Euler-Sombor Bhanhatti index [38]

$$\sum_{uv \in E(G)} \sqrt{[d(u) - 1]^2 + [d(v) - 1]^2 + [d(u) - 1][d(v) - 1]}$$

- variable Euler-Sombor index [17]

$$\sum_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2 + \lambda d(u) d(v)}$$

- cosine-rule generalized Sombor index [51]

$$\sum_{uv \in E(G)} \sqrt{d(u)^2 + d(v)^2 - 2d(u) d(v) \cos \theta}$$

- delta Euler Sombor Bhanhatti index [38]

$$\sum_{uv \in E(G)} \sqrt{[d(u) - \delta + 1]^2 + [d(v) - \delta + 1]^2 + [d(u) - \delta + 1][d(v) - \delta + 1]}$$

- Revan Euler Sombor Bhanhatti index [38]

$$\sum_{uv \in E(G)} \sqrt{[\Delta + \delta - d(u)]^2 + [\Delta + \delta - d(v)]^2 + [\Delta + \delta - d(u)][\Delta + \delta - d(v)]}$$

- Kepler Bhanhatti index [37]

$$\sum_{uv \in E(G)} \left[d(u) + d(v) + \sqrt{d(u)^2 + d(v)^2} \right]$$

- extended Sombor index [1]

$$\sum_{\substack{\{u,v\} \subseteq V(G) \\ u \neq v}} \sqrt{d(u)^2 + d(v)^2}$$

- extended reduced Sombor index [1]

$$\sum_{\substack{\{u,v\} \subseteq V(G) \\ u \neq v}} \sqrt{(d(u) - 1)^2 + (d(v) - 1)^2}$$

- extended average Sombor index [1]

$$\sum_{\substack{\{u,v\} \subseteq V(G) \\ u \neq v}} \sqrt{(d(u) - 2m/n)^2 + (d(v) - 2m/n)^2}$$

- First integral Sombor index [54]

$$\sum_{uv \in E(G)} \int_0^{d(u)} \sqrt{1 + f'(x)^2} dx$$

where $f(x)$ is a positive-valued function with property $f(d(u)) = d(v)$.

- Second integral Sombor index [54]

$$\sum_{uv \in E(G)} \int_0^{d(u)} \sqrt{f(x)} dx$$

- Sombor–Wiener index [45]

$$\sum_{\{u,v\} \subseteq V(G)} \sqrt{d(u)^2 + d(v)^2} d(u, v)$$

where $d(u, v)$ is the distance between vertices u and v .

- Harary-Sombor index [19, 47]

$$\sum_{\substack{\{u,v\} \subseteq V(G) \\ u \neq v}} \frac{\sqrt{d(u)^2 + d(v)^2}}{d(u, v)}$$

- Harary-Euler Sombor index [18]

$$\sum_{\substack{\{u,v\} \subseteq V(G) \\ u \neq v}} \frac{\sqrt{d(u)^2 + d(v)^2 + d(u)d(v)}}{d(u,v)}$$

3 Concluding Remarks

The enormous variety of Sombor-type indices, emerging from a single such index put forwards only a few years ago [13], reveals the great need of researchers in mathematical chemistry to publish. It is much easier to produce and publish a paper by “inventing” a new topological index and then establishing its basic mathematical properties and possible applications, instead of seeking to discover more hidden properties and more hidden applications of earlier existing topological indices.

Of course, many would say that there always is a possibility that the new variant of a topological index will have better applicative properties than the previous ones, or – with much less hope – that the new variant will have more outstanding mathematical properties. Looking at the list presented in this survey, we must conclude that such expectations are hardly ever matched by facts.

Anyway, we deem that the present survey and its list reflects the status and directions of research in modern-time mathematical chemistry.

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