Appendix

Scenic Routing Navigation Using the Geospatial NSF MRI Instrument at FIU

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Extensive prior art provides methods for the optimization of routing based on the criteria of travel time and/or on the cost of travel and/or the distance traveled. Routing can be in various modalities, such as by car, on foot, by bicycle, via public transit, or by boat. A typical method of routing involves building a graph comprised of street segments, assigning a normalized weighted value to each segment, and then applying the weighted-shorted path algorithm to the graph in order to find the best route.

Some users desire that the routing suggestion include consideration pertaining to the scenic architectural quality of the path. For example, a user desires a leisure walk via what she might deem as visually attractive architecture. Disclosed here is a method to quantify such user preferences and said scenic quality and to augment the standard routing methods by giving weight to said scenic quality.

The following figure shows traditional routing optimizing the time and/or distance.

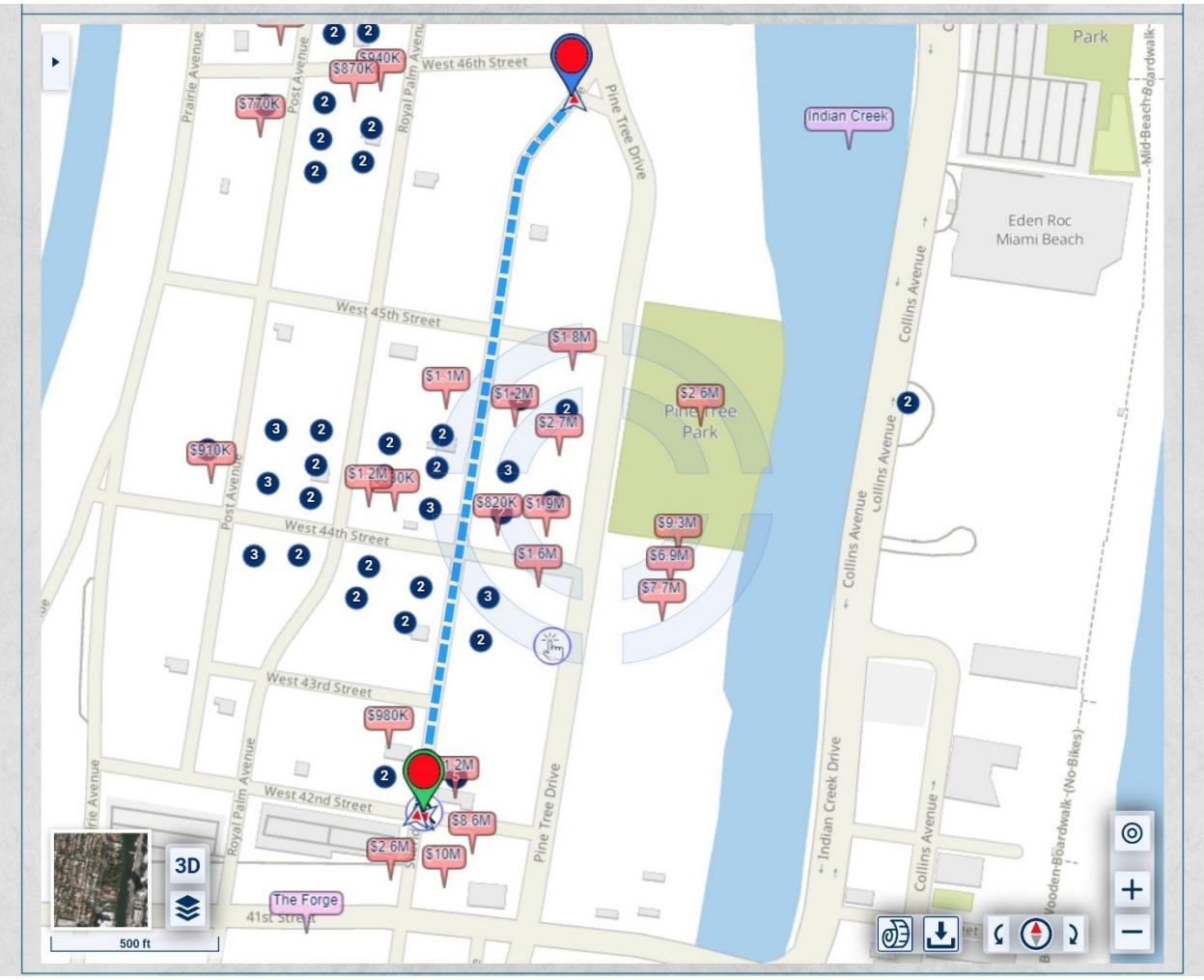


Figure 1. Routing that optimizes time and/or distance

In the previous map, the homes along Pine Tree Drive are much more expensive and, thus, potentially of heavier significance for urban-scenic routing, than along the shortest route. A slightly longer drive or walk, with property values taken into account for urban-scenic routing, would be along Pine Tree Drive as in this map:

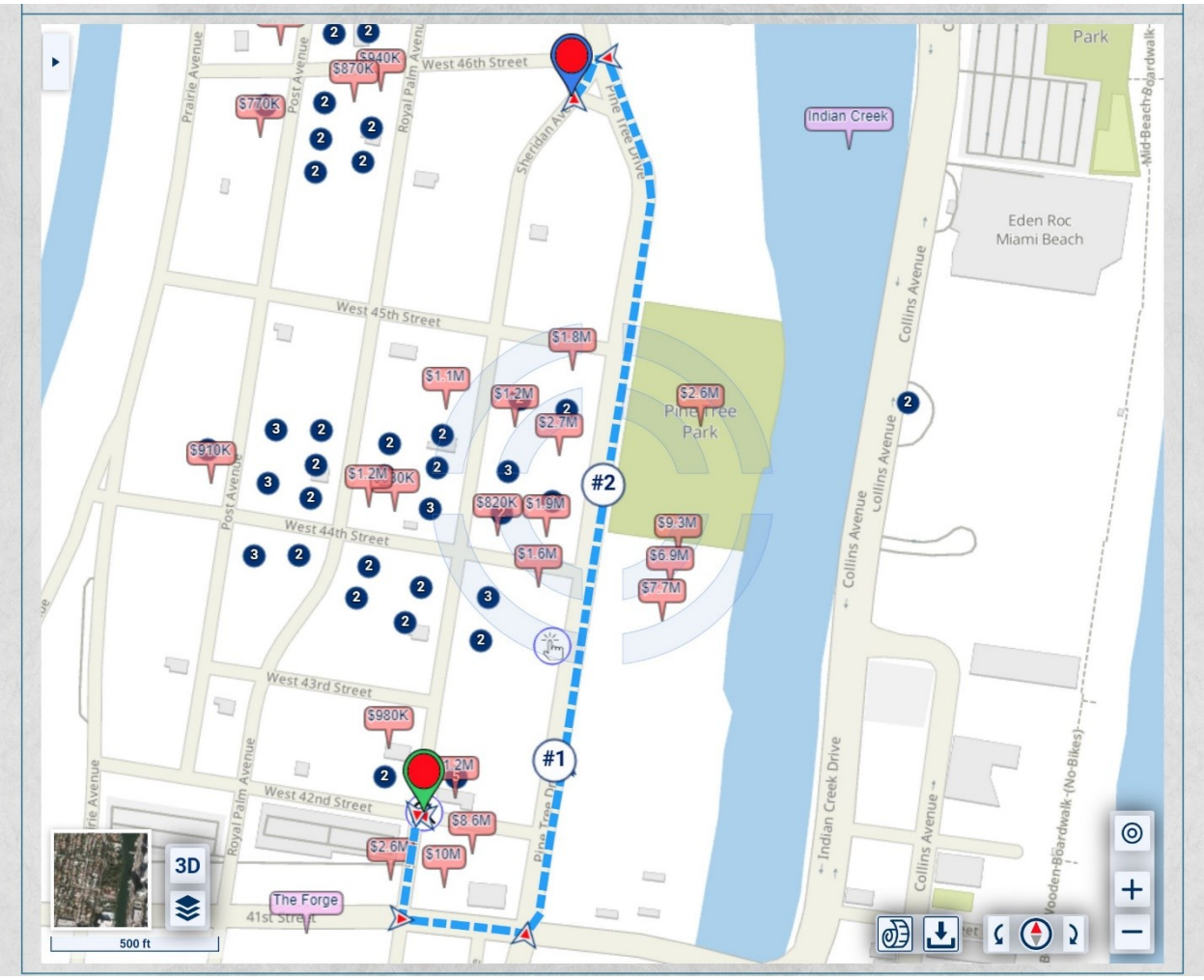


Figure 2. Routing that takes into account urban scenery

If lesser, but not insignificant, weight is assigned to the urban-scenic interest, then the route would be slightly shorter, yet still longer than the shortest route:

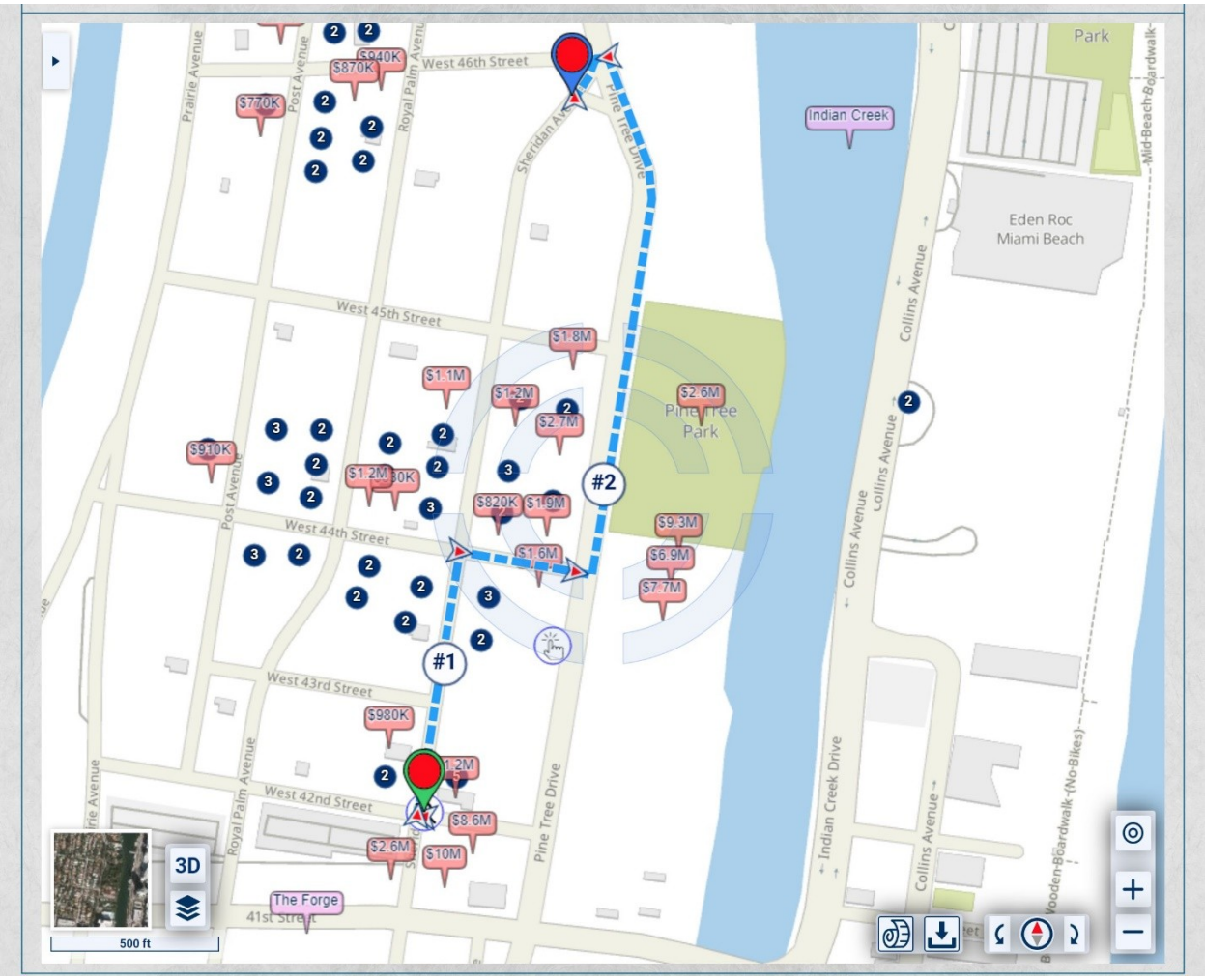


Figure 3. Routing that takes into account urban scenery, according to an embodiment of the subject invention, placing lesser, but not insignificant weight, on urban scenery interest than in the preceding figure

The relative importance of time, cost of travel, and urban-scenic interest can be determined by the user utilizing a prior-art technology of weight selection triangle: a touchable triangle allows the user to assign importance weights to three interrelated decision optimization objectives using a single gesture [Oliver Ullrich, Naphtali Rishe, Daniel Luckerath. U.S. Patent US10061501B2 “User Interface for Co-Optimizing Weight Factors” issued on: August 28, 2018]:

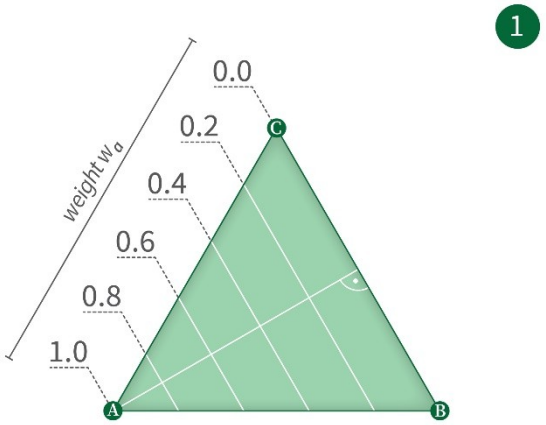


Figure 4. A weighting triangle with values along one side

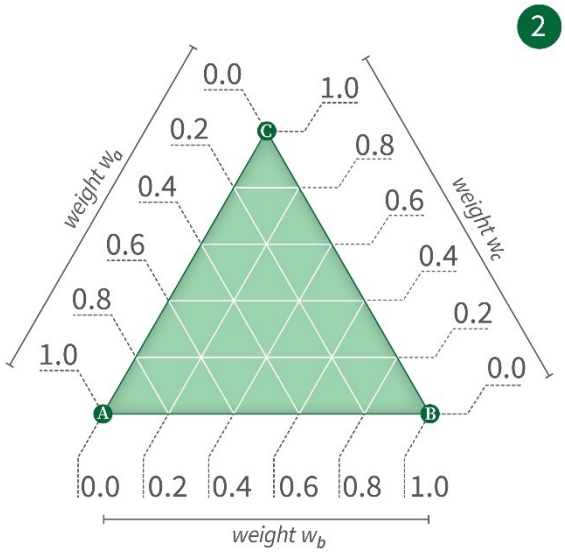


Figure 5. A weighting triangle with weighting values along all three sides

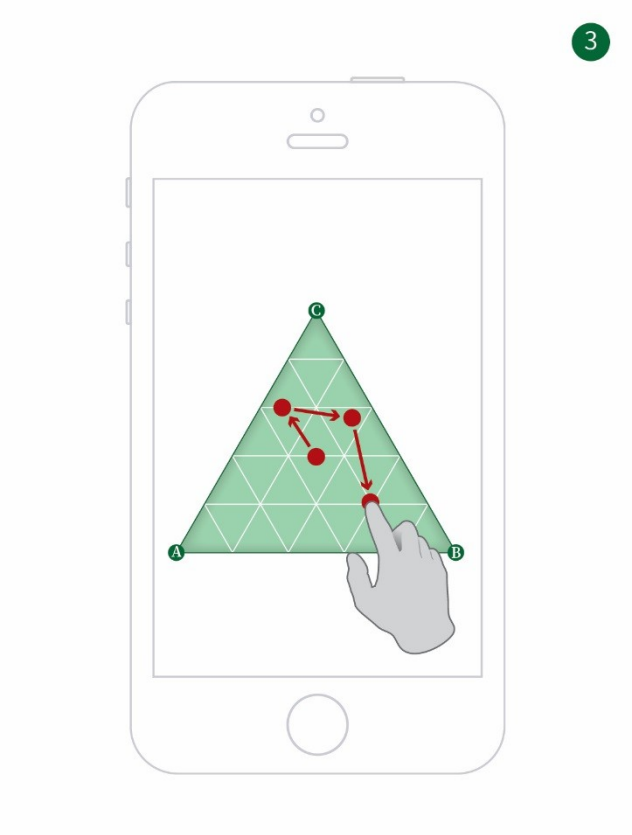


Figure 6. A smart device with the weighting triangle displayed thereon, showing a user selecting different weighting points

Applying said prior-art method to the herein disclosed weighting selection problem, three objectives (*A=time*, *B=cost of travel*, and *C=urban-scenic interest*) are presented in a triangular fashion on a touch screen. Sub-figure 1 shows the underlying principle of the establishment of a single weight w_A for Objective *A*; Sub-figure 2 combines three objectives into a single triangle, allowing for the establishment of a tri-variable weight function (w_A, w_B, w_C). By applying a finger gesture, the user moves an indicator freely inside the triangle (see Sub-figure 3). The position of the indicator establishes a tri-variable weight function, which in further steps is then used as input for a co-optimization algorithm. When the user is satisfied with the established weights, she indicates this, e.g., by pressing a touch screen button labeled "Go."

The mere consideration of property values might include properties of the kind that the user does not consider worthy of observing on her trip, e.g., commercial properties. The user may narrow down the value to be considered in the weighting algorithm to be restricted to certain categories of homes. For example, in the following selection criteria, the user can choose between various property types and select, e.g., only single-family homes:

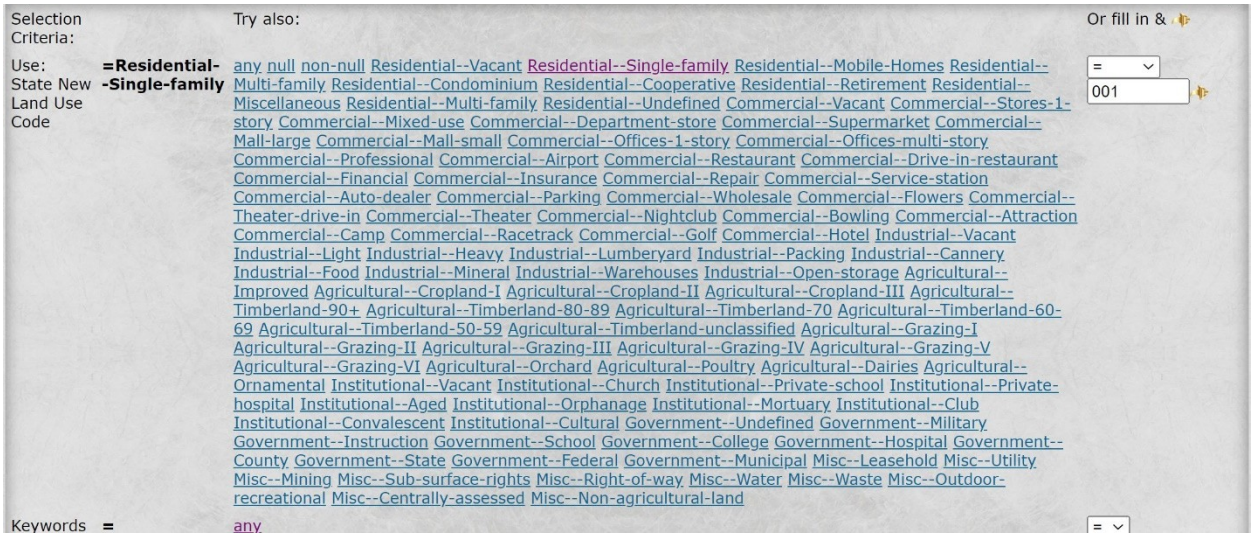


Figure 7. An example of inclusion/exclusion constraint, here the property type, allowing the user to include or exclude certain property types in the evaluation of the scenic values of potential routes

The routing may be changed to remove, for example, commercial properties and multi-family residences from contributing to the urban-scenic routing criterion:

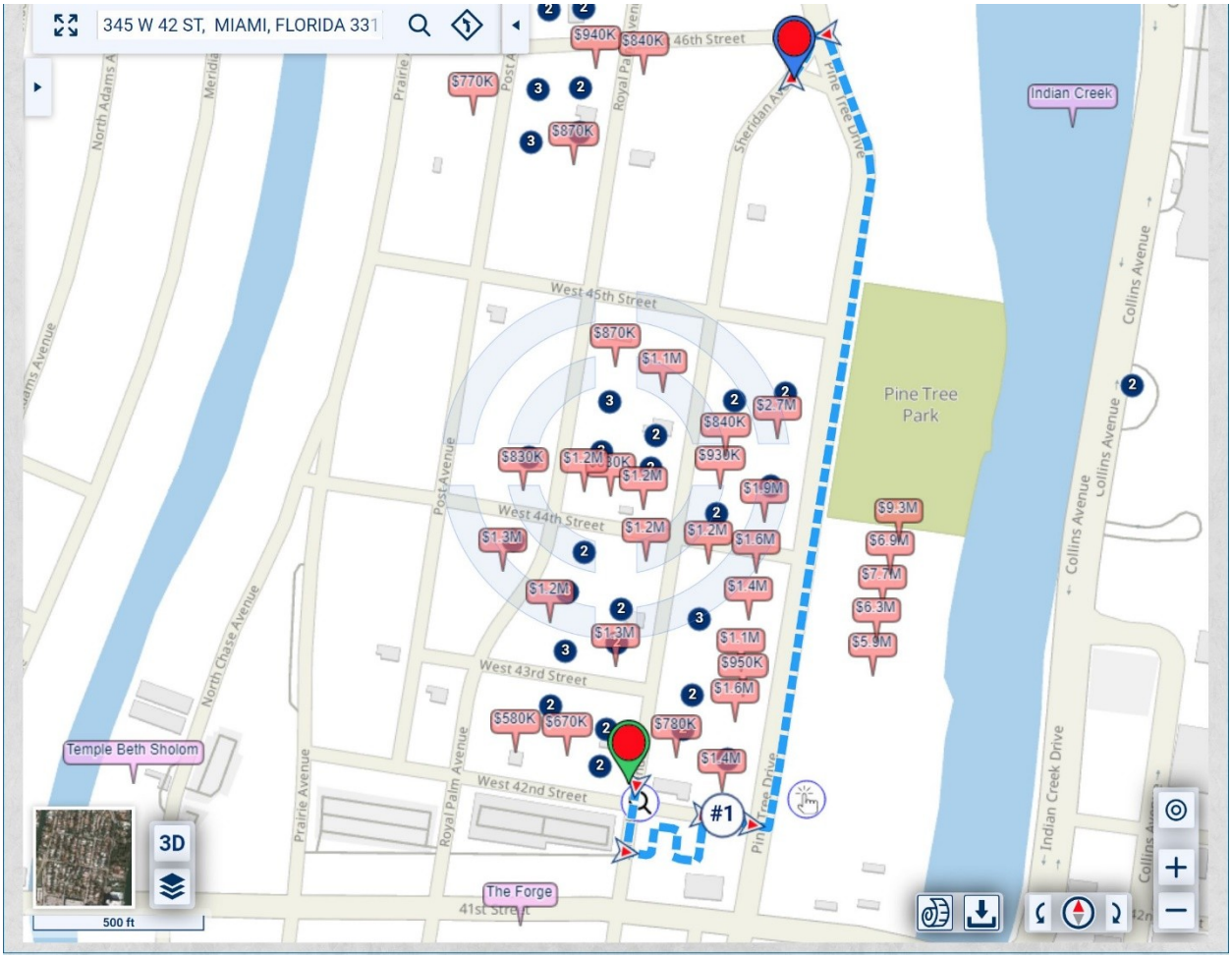


Figure 8. routing that takes into account urban scenery, where the criteria of scenic quality include the values of single-family residential homes

The user may include arbitrarily complex criteria for inclusion or exclusion of types properties in evaluating the urban-scenic interest. For example, the user may choose to select only single-family homes with a lot size of at least 10,000 sq. feet:

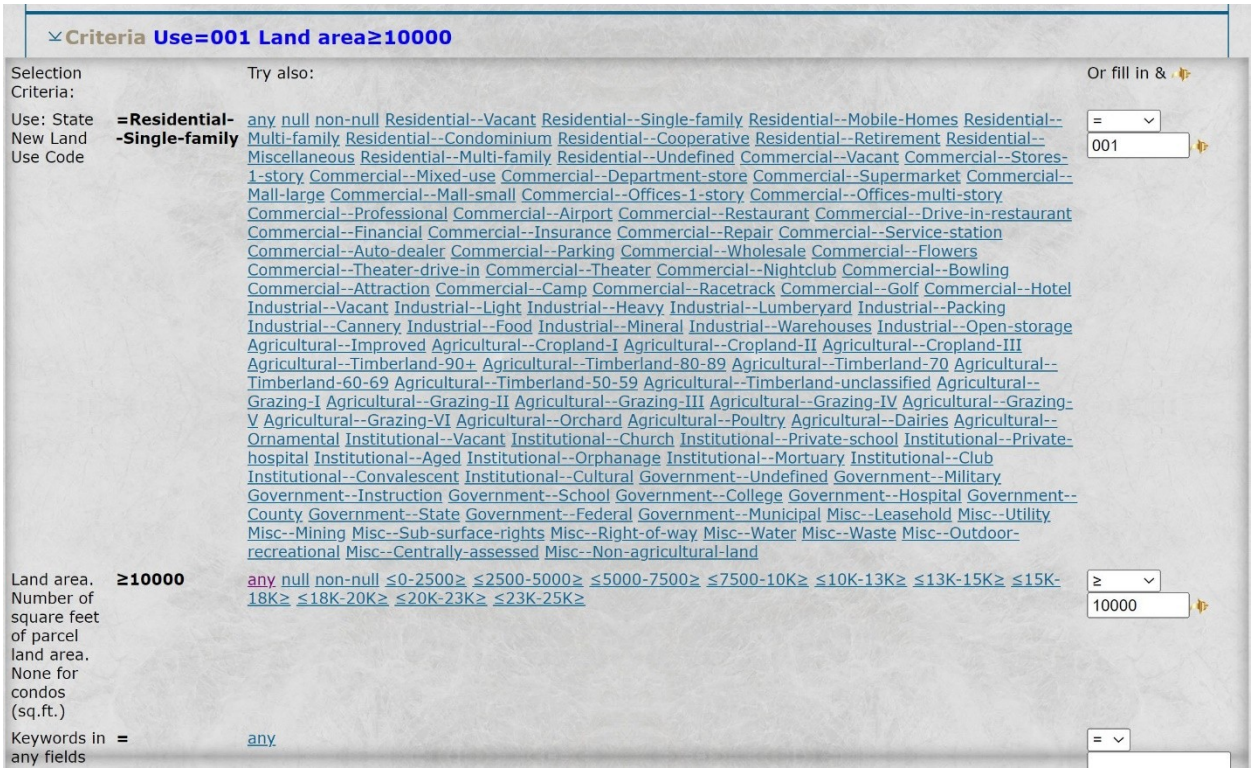


Figure 9. An example of two inclusion/exclusion constraint criteria, namely property type and parcel size, allowing the user to include or exclude certain property types and parcel sizes in the evaluation of the scenic values of potential routes

With certain weights attached to the various criteria, the route may be like this:

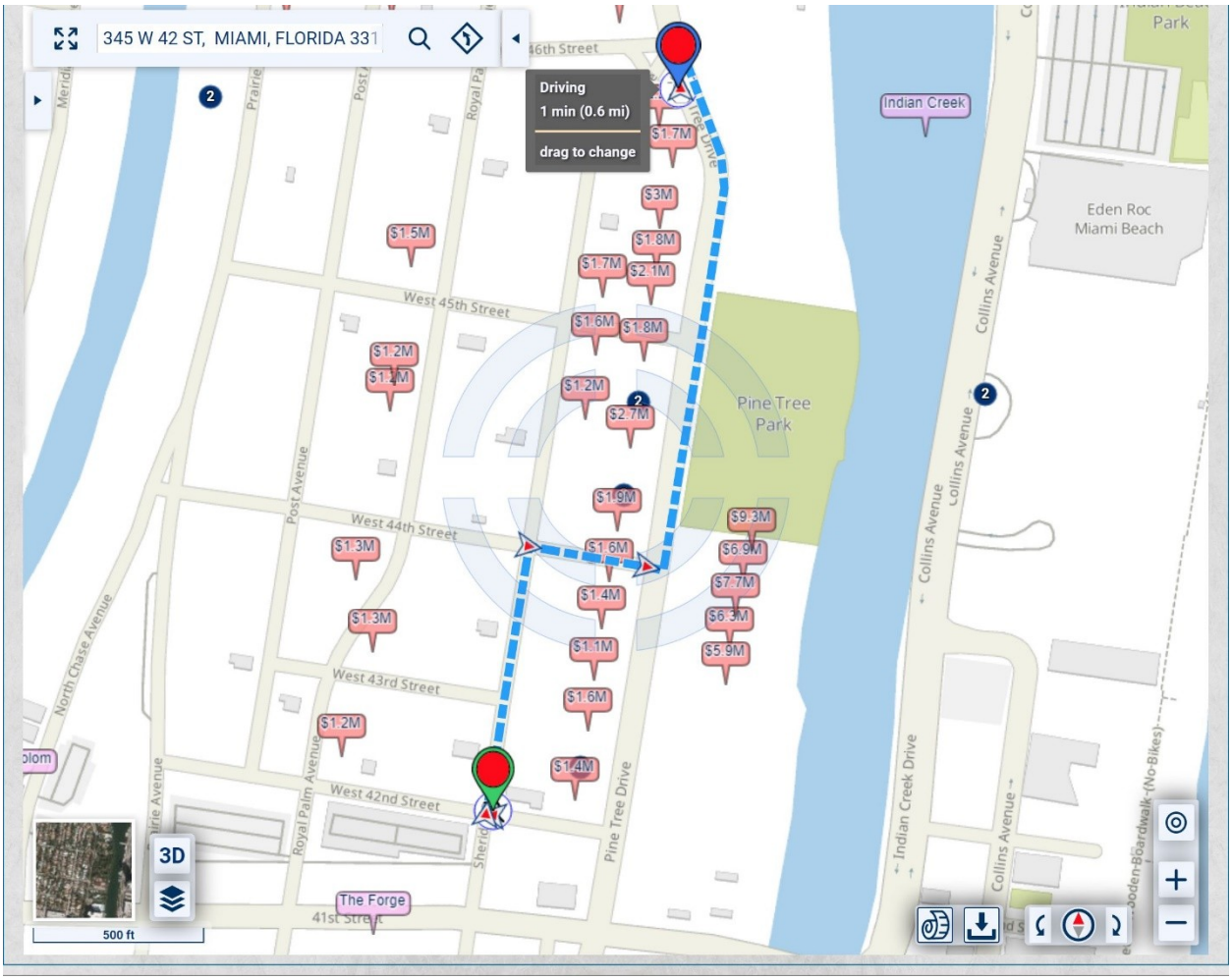


Figure 10. Routing that takes into account urban scenery, based on the inclusion/exclusion criteria constraints depicted in the preceding figure

The routing can be presented to the user via oral instructions, in a graphic form, or in textual form:

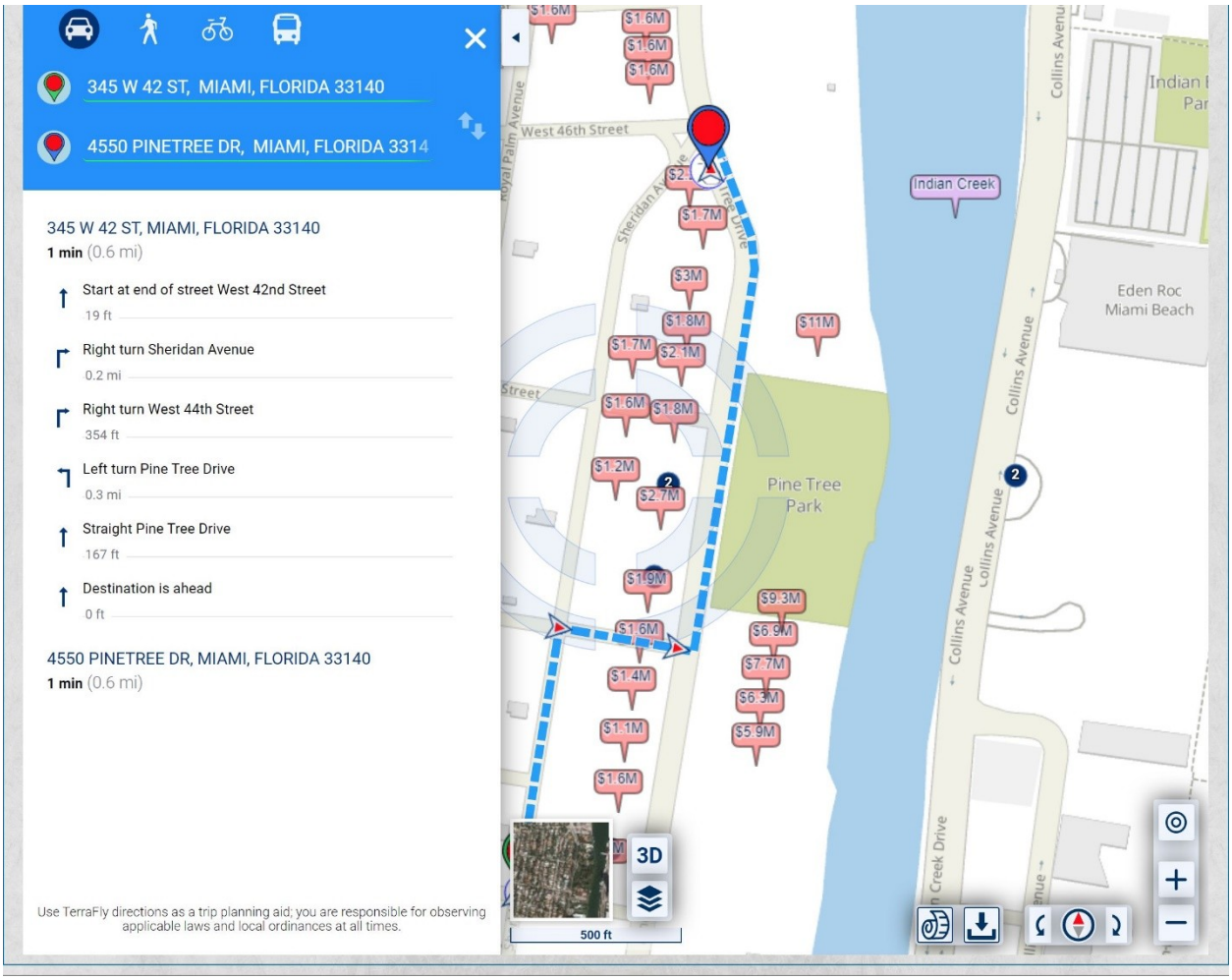


Figure 11. Routing map showing routing steps as well

The weighting desired by the user might be based on the total dollar value of the home or on another related metric, which might better capture the user's needs. For example: the value per square foot:

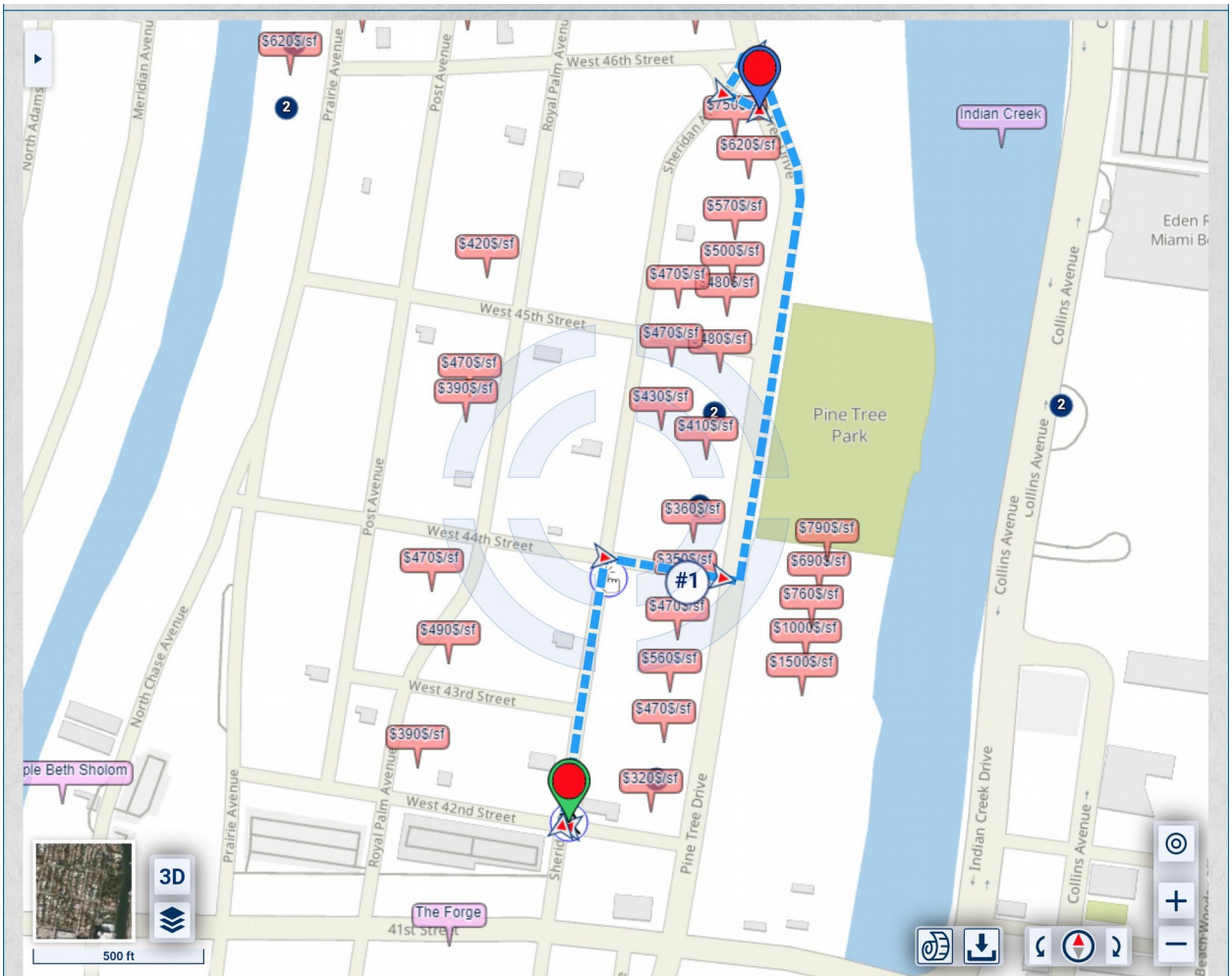


Figure 12. Routing that takes into account urban scenery, where the value per square foot of the properties along the route is displayed, and the scenic quality criteria include the property value per building square foot rather than, or in addition to, the building value

Rather than the entire home value, the value for weighting might be just the value of the structure (what in real estate is called the “improvements”) or the value of the land without the structure (the “unimproved land” value). Here is an example with just the values of the unimproved land:

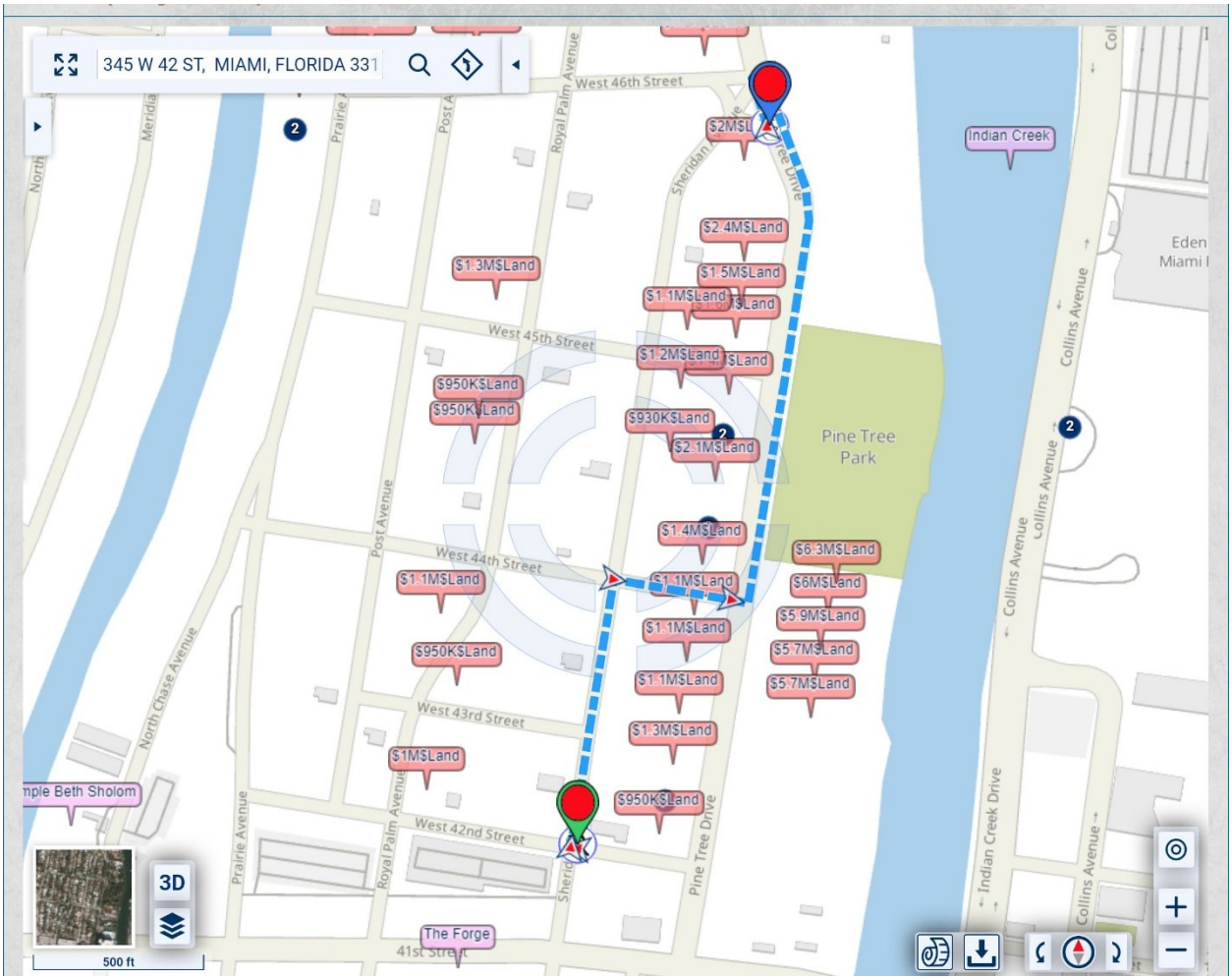


Figure 13. Routing that takes into account urban scenery, where values of unimproved land on properties along the route are displayed

The source of the valuation of each home can be, for example, the assessed value of the home per county records, recent sale price, or current asking price from the MLS records. In the case of a county assessed value, one would typically choose for the purpose of the herein presented weighting an objective value rather than tax valuation, since the latter may be dependent on the property owner's status rather than only on the objective property quality. For example, in Florida, counties publish multiple "values" for the same home, including "the taxable value," i.e., the value against which the property tax is assessed and which takes into account the freezing of homestead property valuation and various discounts to which the current property owner may be entitled. A more objective county-published value in Florida in what the counties call the "Just Value." While it may or may not be a true reflection of the current value of the property, it is objective in the sense that the county applies the same methodology to estimate the "just values" of various properties; thus, it can be useful for the weighting presented herein:

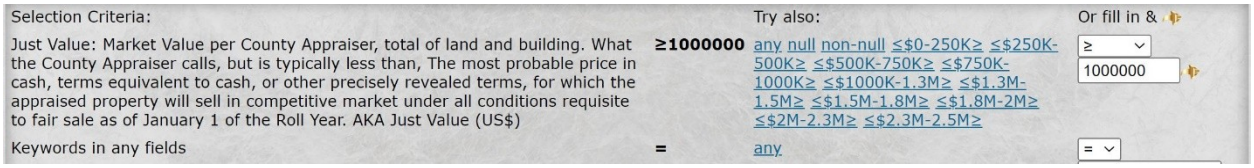


Figure 14. The meta-data of source data of property values, comprising a scenic value weighting criterion

The following example shows the various official “valuations” available from Florida counties. Among these valuations, the most meaningful for urban-scenic routing purposes is the “Just Value,” while the Land-value and Building-value are also meaningful. The other valuations are affected by the demographics of the property owner and, thus, are not meaningful for urban-scenic routing purposes.

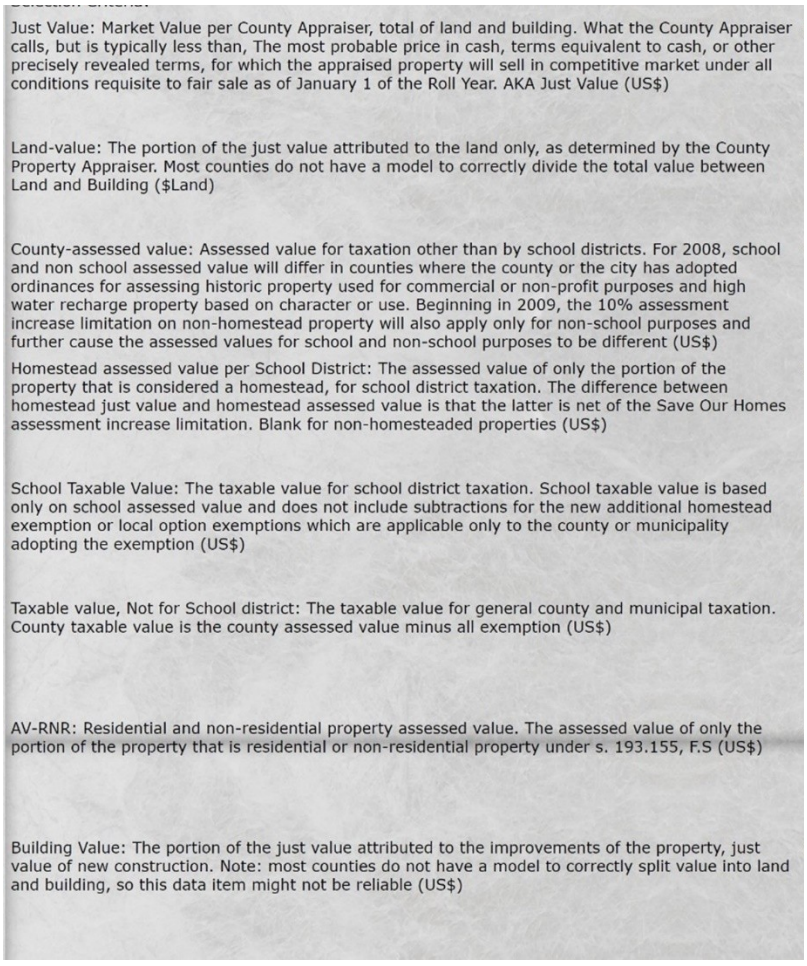


Figure 15. Various types of official valuations of properties, some of which types may be used as source data of property values as a scenic value weighting criterion

Other objective metrics can be computed utilizing the published data. For example, the value per square foot can be computed from the published home value and the published home size:

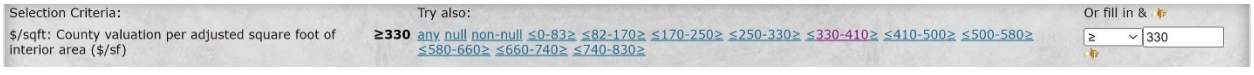


Figure 16. The metadata of an alternative data type that can be used as a scenic value weighting criterion, namely the value per square foot, i.e., the ratio of the official property valuation to the official size of the home on the property

Here is a different example of a source of home values: the current asking price in the real-estate multiple-listing services (MLS):

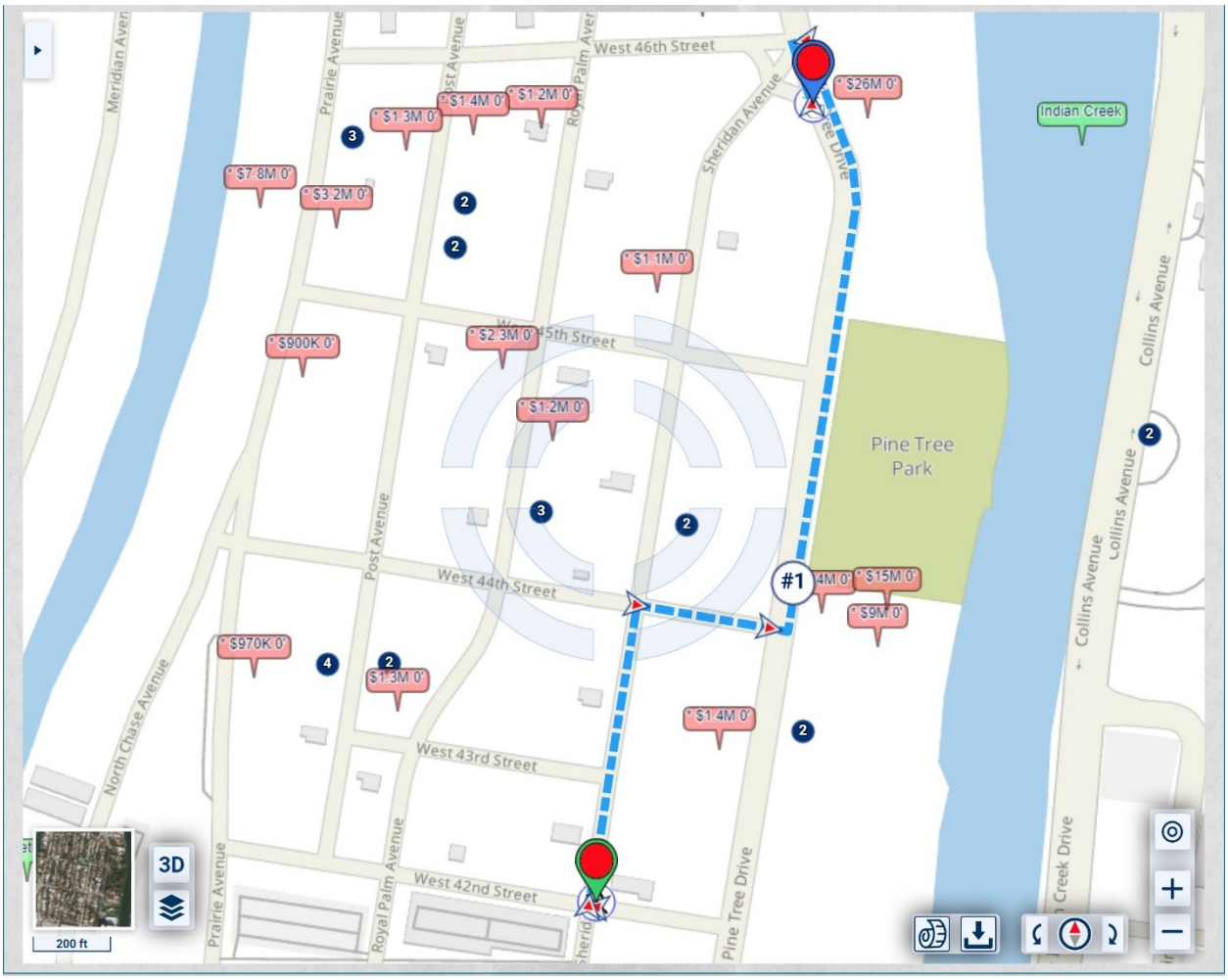
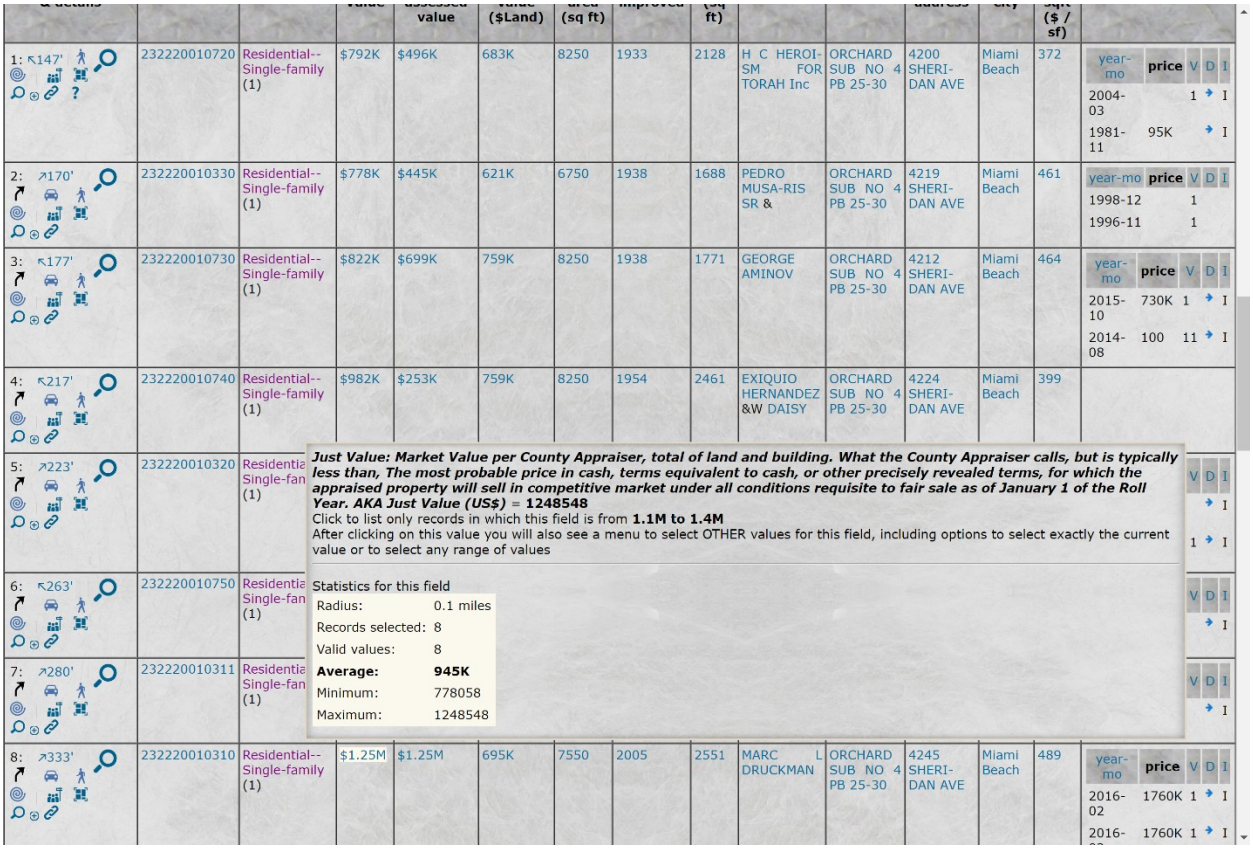


Figure 17. Routing that takes into account urban scenery, where values of properties listed in the real estate multiple listing service (MLS) are displayed and comprise the source data of property values as a scenic value weighting criterion

When the source property value is per-house, it can be translated into value weight per street segment using any appropriate statistical aggregation of data. The following example shows the computation of the Maximum and the Average home value along the 4200 segment of Sheridan Avenue:



			value	($Land)	(sq ft)		ft)					($ / sf)	
1: ↖147'	232220010720	Residential--Single-family (1)	$792K	$496K	683K	8250	1933	2128	H C HEROI-SM FOR TORAH Inc	ORCHARD SUB NO 4 PB 25-30	4200 SHERI-DAN AVE	Miami Beach	372	year-mo price V D I 2004-03 1 I 1981-11 95K I
2: ↗170'	232220010330	Residential--Single-family (1)	$778K	$445K	621K	6750	1938	1688	PEDRO MUSA-RIS SR &	ORCHARD SUB NO 4 PB 25-30	4219 SHERI-DAN AVE	Miami Beach	461	year-mo price V D I 1998-12 1 1996-11 1
3: ↖177'	232220010730	Residential--Single-family (1)	$822K	$699K	759K	8250	1938	1771	GEORGE AMINOV	ORCHARD SUB NO 4 PB 25-30	4212 SHERI-DAN AVE	Miami Beach	464	year-mo price V D I 2015-10 730K 1 I 2014-08 100 11 I
4: ↖217'	232220010740	Residential--Single-family (1)	$982K	$253K	759K	8250	1954	2461	EXIQUIO HERNANDEZ &W DAISY	ORCHARD SUB NO 4 PB 25-30	4224 SHERI-DAN AVE	Miami Beach	399	
5: ↗223'	232220010320	Residentia Single-fan (1)												V D I I 1 I
6: ↖263'	232220010750	Residentia Single-fan (1)												V D I I
7: ↗280'	232220010311	Residentia Single-fan (1)												V D I I
8: ↗333'	232220010310	Residential--Single-family (1)	$1.25M	$1.25M	695K	7550	2005	2551	MARC L DRUCKMAN	ORCHARD SUB NO 4 PB 25-30	4245 SHERI-DAN AVE	Miami Beach	489	year-mo price V D I 2016-02 1760K 1 I 2016- 1760K 1 I

Just Value: Market Value per County Appraiser, total of land and building. What the County Appraiser calls, but is typically less than, The most probable price in cash, terms equivalent to cash, or other precisely revealed terms, for which the appraised property will sell in competitive market under all conditions requisite to fair sale as of January 1 of the Roll Year. AKA Just Value (US$) = **1248548**

Click to list only records in which this field is from **1.1M to 1.4M**

After clicking on this value you will also see a menu to select OTHER values for this field, including options to select exactly the current value or to select any range of values

Statistics for this field

Radius:	0.1 miles
Records selected:	8
Valid values:	8
Average:	**945K**
Minimum:	778058
Maximum:	1248548

Figure 18. Source data allowing the system to compute the maximum and/or average property value along each segment (e.g., along the 4200 segment of Sheridan Avenue in Miami, Florida, United States)

Many other reasonable statistical aggregation functions for the purpose of urban-scenic routing include:

- Median value
- Average value after exclusion of low outliers
- Median of the highest 20% of values
- The number of homes valued at over $1M
- The number of homes valued at $1 to $2M plus double the number of homes valued at over $2M.

While the aforementioned examples considered sourcing property valuation per house and then their aggregation per street segment using various statistical methods, another sample embodiment of the herein present method may use already pre-aggregated property values as may be available, for example, in the United States from the American Community Survey (ACS) or the United States Census (Census). However, said data source examples may have a sparser spatial granularity than a street segment, in which case the urban-scenic routing method would be slightly less precise: for example, the blocks 4200 Sheridan Ave and 4200 Pine Tree Dr are within the same home valuation statistical area in ACS, and they are in the same block group in Census. Furthermore, one street segment may lie on the boundary of two statistical areas, in which case the urban-scenic valuation of the street segment should combine the even side of the street segment and the odd side of the street segment.

After the home values have been aggregated per street segment using, for example, any of the aforementioned per-house or sparser data sources, the aggregated values need to be normalized over the entire relevant map portion. For example, the aggregated values can be normalized into the range of 0 to 1. Thereafter the total normalized value of each street segment can be computed by considering said normalized values in conjunction with other criteria, such as the street segment's expected travel time. Relative weights are assigned to the various criteria, using, for example, the aforementioned touch triangle method.

Once a route is computed, it can be presented to the user for approval.

If the routing is presented to the user in a graphic form, it may be further enhanced in various visual forms to inform the user and let the user visually confirm that the choice of the route shows what the user intended or have the user adjust the relative weights and criteria. For example, overhead imagery of the houses that the user would pass by (on the currently offered route) can be displayed:

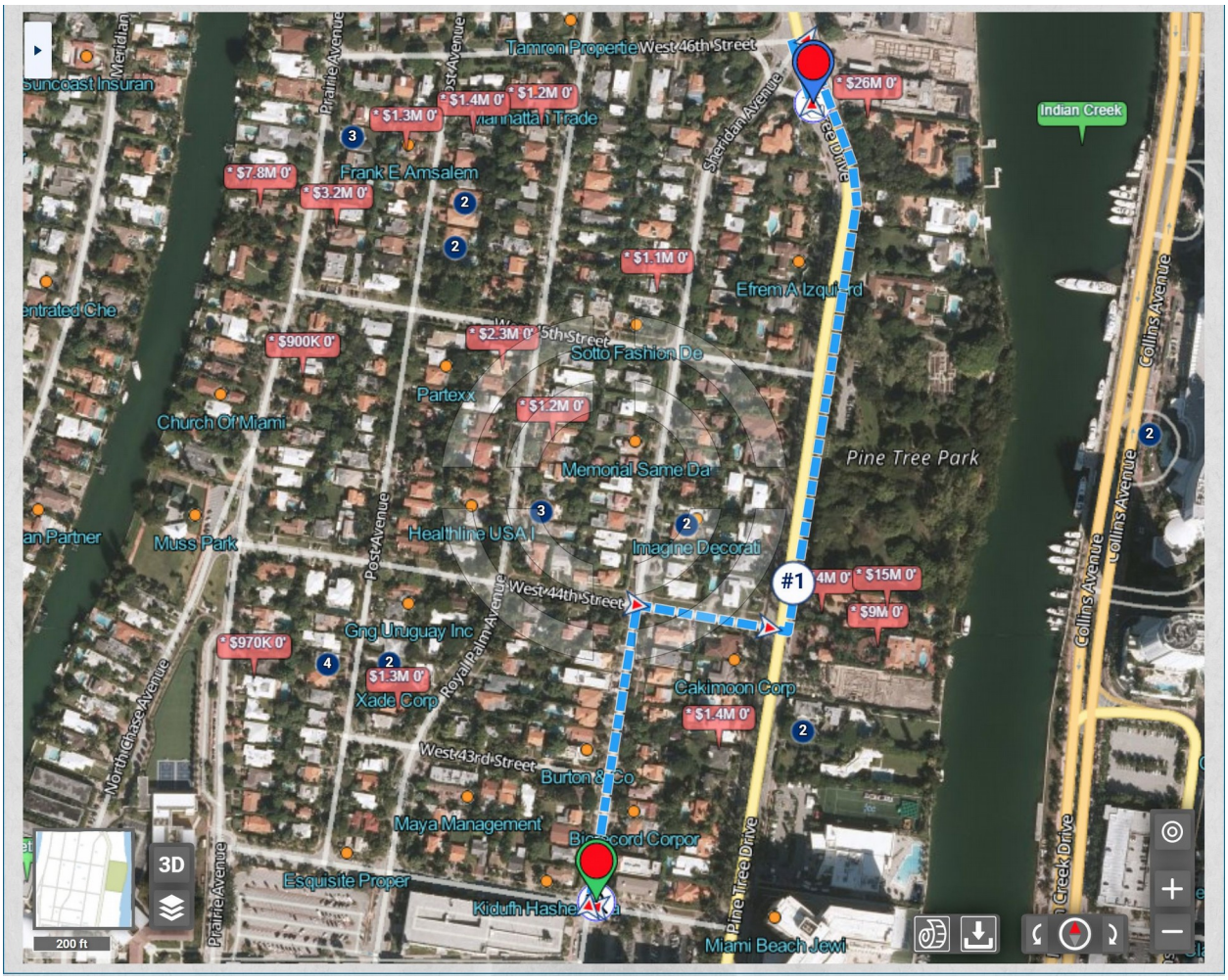


Figure 19. A display of a proposed routing that takes into account urban scenery, where overhead satellite imagery is included in the display in order to better inform the user

Another way is to display photographs of the facades of the houses that the user will encounter:

Figure 20. A display of a proposed of routing that takes into account urban scenery, where images of facades of houses along the route are displayed in order to better inform the user

Another example is to present to the user oblique (bird's eye view) images:

Figure 21. A display of a proposed routing that takes into account urban scenery, where oblique or bird's eye images of houses along the proposed route are displayed in order to better inform the user