# Finding the Lovasz Number

## Adam Rahman

## October 26, 2024

The Lovasz Number of a graph $\mathbf{G}$, denoted $\vartheta(\mathbf{G})$, is the upper bound on the Shannon capacity of the graph ([1]). For an adjacency matrix $\mathbf{B} = [B_{ij}]$ the problem of finding the Lovasz number is given by the following primal SQLP problem

$$
\begin{aligned}
\underset{\mathbf{X}}{\text{minimize}} \quad & tr(\mathbf{CX}) \\
\text{subject to} \quad & \\
tr(\mathbf{X}) \ &= \ 1 \\
X_{ij} \ &= \ 0 \quad \text{if } B_{ij} = 1 \\
\mathbf{X} \ &\in \ \mathcal{S}^n
\end{aligned}
$$

The function `lovasz` takes as input an adjacency matrix `B`, and returns the the optimal Lovasz number using `sqlp`.

```
R> out <- lovasz(B)
```

## Numerical Example

To compute the Lovasz number using `sqlp`, we need only the (weighted) adjacency matrix representing a graph object.

```
R> data(Glovasz)
```

```
       V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
 [1,]   0  0  0  1  0  0  1  1  0   0
 [2,]   0  0  0  1  0  0  1  0  1   1
 [3,]   0  0  0  0  0  0  0  1  0   0
 [4,]   1  1  0  0  0  0  0  1  0   1
 [5,]   0  0  0  0  0  0  1  1  1   1
 [6,]   0  0  0  0  0  0  0  0  1   0
 [7,]   1  1  0  0  1  0  0  1  1   1
 [8,]   1  0  1  1  1  0  1  0  0   0
 [9,]   0  1  0  0  1  1  1  0  0   1
[10,]   0  1  0  1  1  0  1  0  1   0
```

The Lovasz number for the associated graph is the value of the primal objective function. Again, since the objective function was negated to make the primal problem a minimization, we negate the value of the objective function.

```
R> out <- lovasz(Glovasz)
```

```
R> -out$pobj
```

```
[1] 5
```

# References

[1] László Lovász. On the shannon capacity of a graph. *IEEE Transactions on Information theory*, 25(1):1–7, 1979.