* 3.2.2

When the manipulator is in static equilibrium, the loads that act on it are balanced by the torques generated at the joints. Considering that the joints are passive, the torque is generated by their elasticity and not by motors.

The joint torque (τi) at the *i*-th joint is given by the following relation: (3.4), where Kθ,i is the flexural stiffness and qθ,i is the amount of bending.

For a continuum manipulator with *n* rigid links connected by *n* joints, the joint torque vector due to unknown external forces can be calculated using (3.5) and it is given by (3.6), where **J**Tcp ∈ R2×n is the contact point Jacobian, **F**ext ∈ R2 is the external wrench.

The bending moment at the i-th joints produced by external forces is neglected.

* 3.2.3

Each joints has one degrees of freedom, joint angle qθ,i. The absolute angle at *i-th* joint (qθ,i∗) can be related to the manipulator shape using (3.7), while the amount of bending at *i-th* joint is calculated using (3.8).

Liy and Lix (provided by the FBG sensor measurements) are the distance between the origin of Frame *i* and the origin of Frame *i+1* along yi and xi, respectively.